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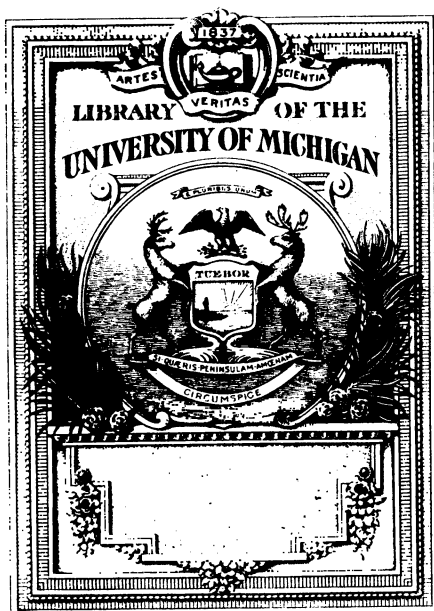
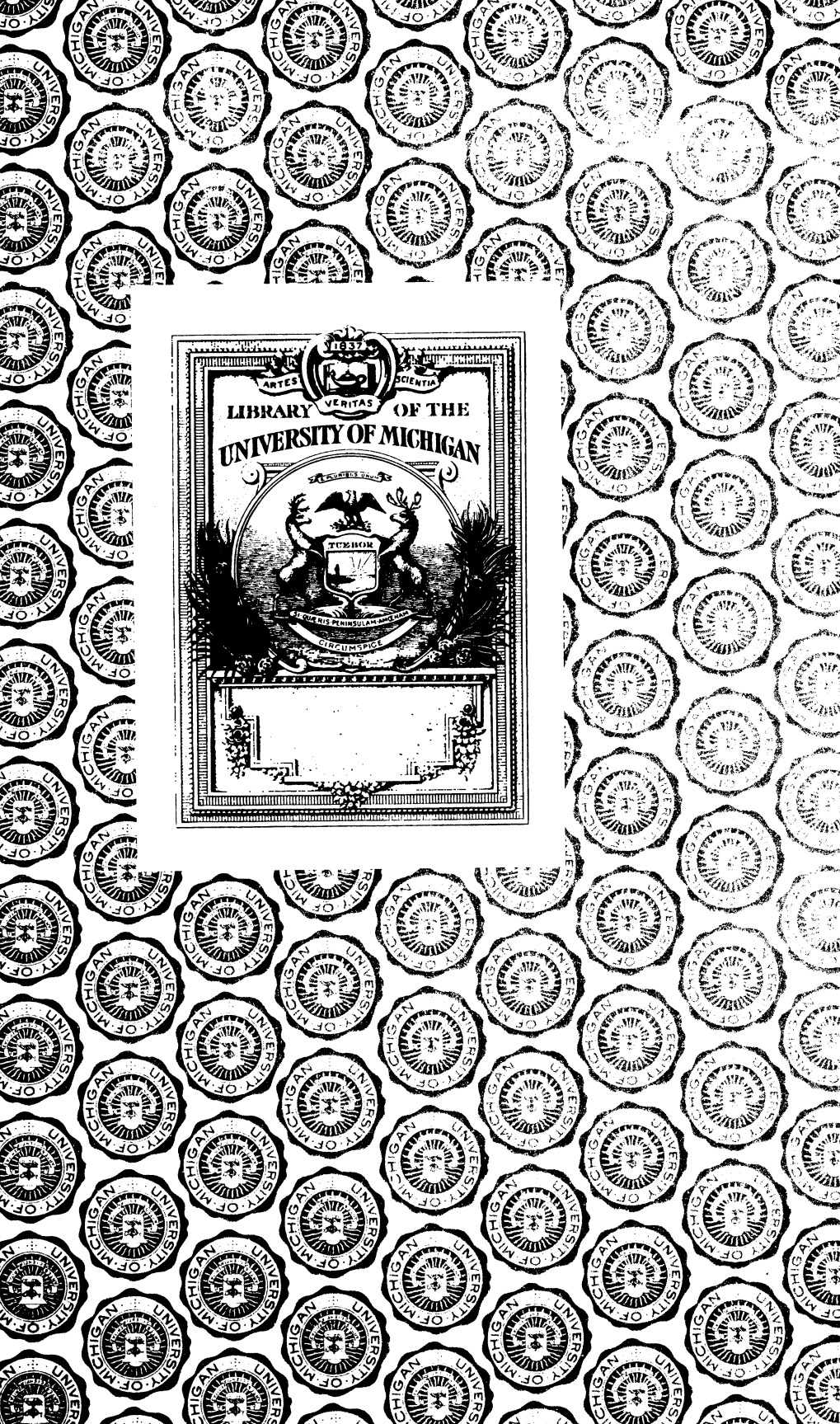
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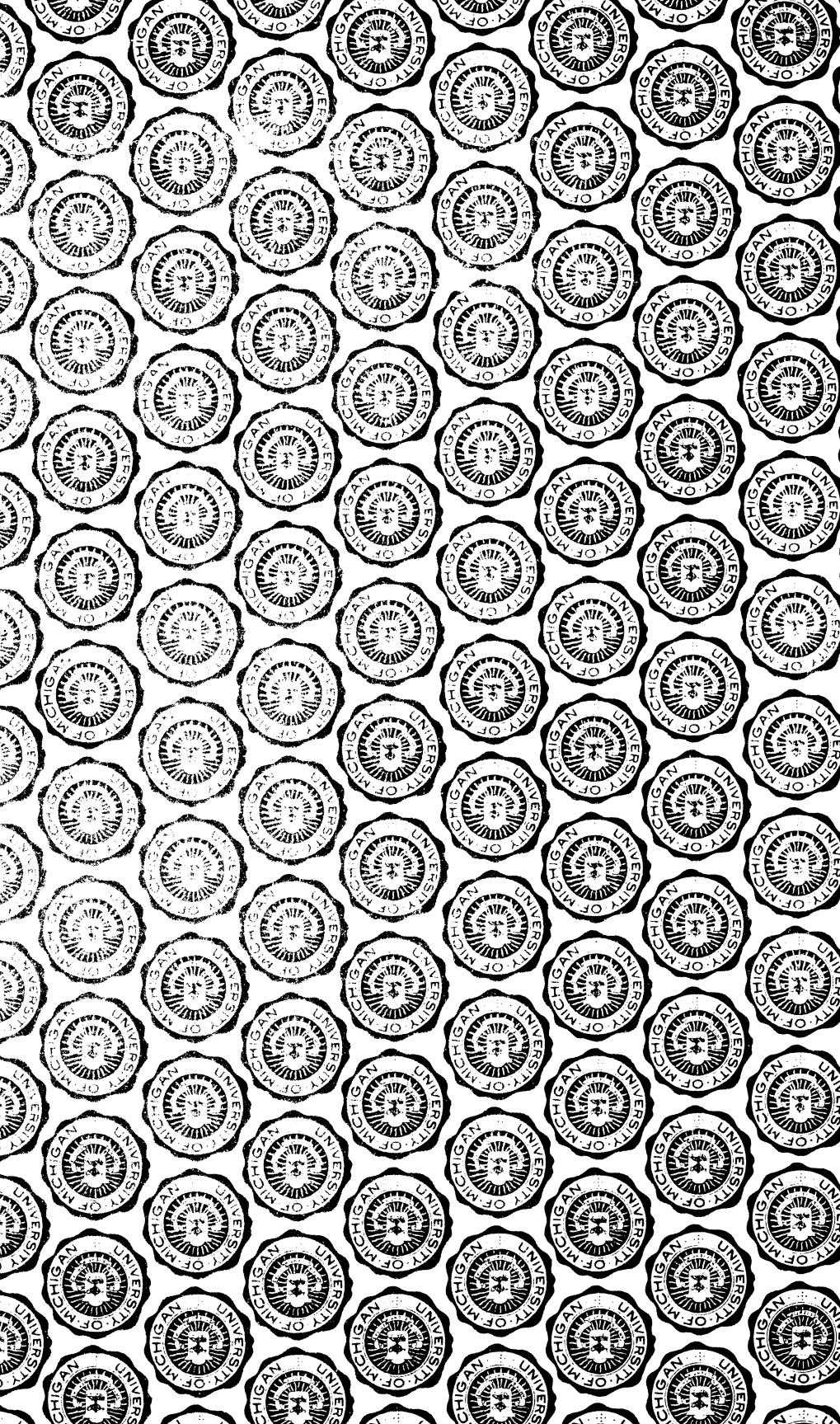
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WITH 69 PLATES AND 21 TEXT FIGURES



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THE PHILIPPINE JOURNAL OF SCIENCE

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JANUARY, 1928

No. 1

NOMENCLATURAL NOTES ON PHILIPPINE PLANTS

By ELMER D. MERRILL

Of the University of California, Berkeley

Through the courtesy of Dr. Edwin Bayer, of the National Museum, Prague, I recently had the opportunity of examining several hundred unnamed Philippine specimens collected by Haenke under the auspices of the Malaspina Expedition. At the same time a number of Presl's types were loaned to me, from an examination of which it has been possible definitely to place several of his proposed species that were previously, because of incomplete descriptions, considered as of doubtful status. In species more recently described it has become necessary to propose new specific names, because those originally published by me were preoccupied. As the type of the genus *Plectronia* has been shown to be identical with *Olinia*, this generic name is abandoned in the Rubiaceæ and the Philippine species there placed are transferred to *Canthium*.

GRAMINEÆ

Genus *ARISTIDA* Linnæus

ARISTIDA SORZOGONENSIS Presl.

Aristida sorzogonensis PRESL, Rel. Haenk. 1 (1830) 224.

In my Enumeration of Philippine Flowering Plants¹ I placed this under the excluded species, with the comment that the record (Sorsogon) was probably based on an erroneously labeled specimen, the species in all probability being American. An examination of Presl's type in the Prague Herbarium shows

¹ Bur. Sci. Publ. No. 18 1 (1922) 80.

that the species is a true *Aristida*, but is remote from all of the few known Philippine species. Prof. H. G. Hitchcock states that it is not any of the species of the United States, and does not match any of the species of Ecuador, Peru, and Bolivia known to him. I still believe that the actual type was from either South America, the west coast of North America, or possibly Australia, although it is possible that a Philippine species is represented that has not appeared in the extensive Philippine collections made since Haenke's time. Professor Hitchcock further states that at first he took the species to represent *Aristida setifolia* HBK. of tropical America, but that the callus does not agree with that of the latter species.

Genus SETARIA Beauvois

SETARIA GLOBULARIS Presl.

Setaria globularis PRESL, Rel. Haenk. 1 (1830) 314; SCRIBNER in Rept. Missouri Bot. Gard. 10 (1899) 52.

This was based on a Haenke specimen, "Hab. in insulis Philippinis," but is manifestly not a Philippine plant and was excluded by me. Scribner states that the sheet in the Bernhardt Herbarium at the Missouri Botanical Garden represents three species; one *Setaria caudata* Lam., as interpreted by him, one *S. composita* Kunth, the third not determinable. The specimen in the Prague Herbarium represents a single species. Regarding the fragment forwarded to him for examination Professor Hitchcock states that it matches two specimens collected by Mrs. Chase in Brazil that had tentatively been placed under *Setaria rariflora* Presl and which may represent *Setaria caudata* of Brazilian authors, but not *Setaria caudata* Lam. of the West Indies. Haenke's specimen and the two specimens collected by Mrs. Chase differ from the species mentioned above in having prominently rugose fruit. Professor Hitchcock states that he does not see how Presl could have secured Brazilian material. The species is safely not Philippine.

Genus PASPALUM Linnæus

PASPALUM BORYANUM Presl.

Paspalum boryanum PRESL, Rel. Haenk. 1 (1828) 209; MERR., Enum. Philip. Fl. Pl. 1 (1922) 57.

In the Enumeration of Philippine Flowering Plants this is placed under the excluded species, with the comment that it may prove to be a *Digitaria*, or some American species of *Paspalum*, although Presl's type was localized as from Sorsogon, Luzon. I have recently had the opportunity of examining Presl's type

in the Prague Herbarium, and it is identical with the Philippine form I have referred to *Paspalum vaginatum* Sw., but which Hackel referred to *Paspalum distichum* Linn.; see Kneucker *Gram. exsic.* 805 from Rizal Province, Luzon, which is identical with *Paspalum boryanum* Presl. Professor Hitchcock confirms this identification as *Paspalum distichum* Sw.

Genus SPOROBOLUS R. Brown

SPOROBOLUS SCOPARIUS Presl.

Sporobolus scoparius PRESL, Rel. Haenk. 1 (1830) 243.

On the assumption that the species described by Presl was a *Sporobolus*, type from Sorsogon, Luzon, I stated:² "Certainly not a Philippine species, but probably based on American material." An examination of Presl's type in the Prague Herbarium clearly shows that *Sporobolus scoparius* Presl is identical with the common and widely distributed *Thysanolaena maxima* (Roxb.) O. Kuntze = *Thysanolaena procera* (Retz.) Mez in Bot. Archiv 1 (1922) 27; *Agrostis procera* Retz., Obs. 4 (1779) 19. The name *Thysanolaena procera* (Retz.) Mez is the oldest valid one for this species. The panicles are commonly used in making brooms in the Philippines, whence Presl's specific name.

Genus BROMUS Linnæus

BROMUS LUZONENSIS Presl.

Bromus luzonensis PRESL, Rel. Haenk. 1 (1828) 262 "Hab. in Luzonia," Presl.

Of this I have seen a single detached spikelet, without its pedicel. I still believe that the material could not possibly have originated in the Philippines. Regarding the fragment, Professor Hitchcock states that he has not been able to determine it satisfactorily, although the spikelet compares very well with *Bromus lanatus* HBK., a species of tropical America; Presl's description does not agree, as he describes it as having short stiff pedicels, while *Bromus lanatus* HBK. has rather slender curved ones. It is indeed difficult to determine why Kunth referred this species to *Triticum*; it is a true *Bromus*.

Genus DIGITARIA Scopoli

PASPALUM MOLLE Presl, Rel. Haenk. 1 (1828) 213 "Hab. in Luzonia," Presl.

The specimen in the Prague Herbarium is a *Digitaria*. Regarding it Professor Hitchcock states that it matches three specimens in the United States National Herbarium; namely,

² An Enumeration of Philippine Flowering Plants 1 (1922) 81.

Ramos 1125, from British North Borneo, and two specimens collected by himself, one near Canton, China, the other at Dong Hoi, Annam. These were placed under *Digitaria longiflora* (Gmel.) Pers., but marked *plant villous*. Professor Hitchcock states that it may represent a distinct species. In view of the fact that Presl's type matches oriental material, the locality cited is undoubtedly correct. *Paspalum mollicomum* Kunth and *Syntherisma molle* Scribner are synonyms.

PASPALUM FUSCUM Presl, Rel. Haenk. 1 (1828) 214 "Hab. in Luzonia ? in Peruviae montanis huanoccensibus ? Mexico ?"

There are two specimens on the sheet in the Prague Herbarium, one with two spikes, the other with ten spikes; Scribner's figure of the cotype in the Berhardi Herbarium represents a specimen with four or five spikes.³ Professor Hitchcock thinks that the small specimen with two spikes is *Digitaria longiflora* (Gmel.) Pers., and that the larger specimen with ten spikes, which is manifestly the type, as Presl's description states that the spikes are eight to thirteen, is *Digitaria chinensis*. The statement "culmo repente" probably refers to *Digitaria longiflora* (Gmel.) Pers. Presl's name, being the earlier, is here adopted.

DIGITARIA FUSCA (Presl) comb. nov.

Paspalum fuscum PRESL, Rel. Haenk. 1 (1828) 214; KUNTH, Enum. 1 (1833) 46.

Paspalum fliculme Nees ex THWAITES, Enum. Pl. Zeyl. (1864) 358.

Digitaria violascens MERR., Fl. Manila (1912) 88, non Link.

Syntherisma fusca SCRIBNER, Rept. Missouri Bot. Gard. 10 (1899) 49, t. 11.

Paspalus chinense Nees in HOOK. and ARN., Bot. Beechey's Voy. (1841) 231.

Digitaria chinensis MERR., Enum. Philip. Fl. Pl. 1 (1922) 53, here by error credited to Nees.

By many authors this is considered as synonymous with *Digitaria longiflora* (Gmel.) Pers.

CYPERACEÆ

Genus CYPERUS Linnæus

CYPERUS LUZONENSIS Presl.

Cyperus luzonensis PRESL, Rel. Haenk. 1 (1828) 174.

Because of the characters given by Presl in the original description, type from Luzon, and as I was unable to place the species from the description alone, I considered this under the

³ Rept. Missouri Bot. Gard. 10 (1899) t. 11.

doubtful and excluded species of *Pycreus*. An examination of the type in the Prague Herbarium shows *Cyperus luzonensis* Presl to be identical with the common and widely distributed *Cyperus pilosus* Vahl.

CYPERUS MINUTIFLORUS Presl.

Cyperus minutiflorus PRESL, Rel. Haenk. 1 (1830) 251; MERR., Enum. Philip. Fl. Pl. 1 (1922) 109, cum syn.

This was placed by me under the doubtful and excluded species because of the inadequate description. An examination of a fragment of the type from the Prague Herbarium indicates that it is a juvenile form of the common and widely distributed *Cyperus haspan* Linn. *Cyperus minutiflorus* Presl and its synonyms *C. micranthus* Presl non Nees, *C. breviflorus* Dietr., and *C. multiflorus* Kunth thus become synonyms of the Linnean species.

CYPERUS PHILIPPENSIS Presl.

Cyperus philippensis PRESL, Rel. Haenk. 1 (1828) 174.

This species was placed by me under the doubtful and excluded species, the type being from Luzon. An examination of a small fragment of the type, an immature specimen, seems to indicate that a form of *Torulinium ferax* (L. C. Rich.) Ham. is represented, and I make this tentative reduction of Presl's species.

CYPERUS ALBUS Presl.

Cyperus albus PRESL, Rel. Haenk. 1 (1828) 175.

This was placed by me under the doubtful and excluded species of *Pycreus*, because of Presl's description stating that it has two style arms. The type was from Luzon. I have seen only a very small fragment of Haenke's specimen, and most of the styles are two-armed; it does not appear, however, to be a *Pycreus*, but is suggestive of *Cyperus stoloniferus* Retz., which it probably represents. An unnamed specimen from Mexico, *Palmer 377*, also rather closely resembles Haenke's specimen, as far as comparisons are possible with merely very fragmentary material of the latter.

Genus FIMBRISTYLIS Vahl

FIMBRISTYLIS PILOSA Vahl.

Fimbristylis pilosa Vahl, PRESL, Rel. Haenk. 1 (1828) 191.

The identification of Haenke's Sorsogon plant as representing Vahl's species is probably correct. In placing the record of this as Philippine under the doubtful and excluded species I stated that the specimen probably represents a form of *Fimbristylis*

annua R. and S. An examination of Haenke's specimen shows this to be the correct disposition of this Philippine record.

FAGACEÆ

Genus QUERCUS Tournefort

QUERCUS BUDDII nom. nov.

Quercus robinsonii MERR. in Philip. Journ. Sci. 10 (1915) Bot. 297, non Ridl. (1914).

Synaedrys robinsonii KOIDZ. in Bot. Mag. Tokyo 30 (1916) 192.

Lithocarpus robinsonii REHD. in Journ. Arnold Arb. 1 (1919) 130.

My original specific name for the species of central Luzon is invalidated by *Quercus robinsonii* Ridl., a species of the Malay Peninsula described one year earlier. The new name proposed here is derived from Dr. C. B. Robinson's middle name.

TILIACEÆ

Genus BROWNLOWIA Roxburgh

BROWNLOWIA ARGENTATA Kurz.

Brownlowia argentata KURZ in Journ. As. Soc. Bengal 39² (1870) 67; SCHEFF. in Nat. Tijds. Ned. Ind. 34 (1874) 94.

Brownlowia riedelii HEMSL., Bot. Challenger Exped. 1³ (1885) 128; MERR., Enum. Philip. Fl. Pl. 3 (1923) 22; RIDL., Fl. Malay Penin. 1 (1922) 292.

Brownlowia lepidota WARB. in Bot. Jahrb. 18 (1893) 200.

Malay Peninsula, Borneo, Mindanao, Moluccas, Wetter, New Guinea, along tidal streams and on or near the seashore.

Kurz's type was from Buru Okie (Boeroe-oki) in the Moluccas, a specimen collected by Teysmann. The native name cited by him, *atún laut* (*laut*, ocean), clearly indicates that Teysmann's specimen was a strand plant. The description in all respects applies to the form later described by Hemsley as *Brownlowia riedelii*, type from Wetter, near the west end of Timor, south-eastern Moluccas, and still later by Warburg as *Brownlowia lepidota*, type from Finschhafen, New Guinea.

MELASTOMATACEÆ

Genus MEMECYLON Linnæus

MEMECYLON LITTORALE nom. nov.

Memecylon revolutum MERR. in Philip. Journ. Sci. 8 (1913) Bot. 226; Enum. Philip. Fl. Pl. 3 (1923) 216, non Thwaites.

This new name for the species of northern Luzon is needed, as the one I originally used is preoccupied for the Ceylon species described by Thwaites.

SYMPLOCACEÆ

Genus SYMPLOCOS Jacquin

SYMPLOCOS ILOCANA nom. nov.

Symplocos brachybotrys MERR. in Philip. Journ. Sci. 14 (1919) 447,
non Merr. in Journ. Straits Branch Roy. As. Soc. 76 (1917) 110.

Luzon, Ilocos Norte Province, *Bur. Sci.* 33277 Ramos.

A new name is needed for this Philippine species, as in publishing it I overlooked the fact that I had already used the same name for an entirely different Bornean species.

RUBIACEÆ

Genus CANTHIUM Lamarck

(*Plectronia* auctt., non Linn.)

It becomes necessary to adopt Lamarck's generic name for the group which many modern botanists have designated as *Plectronia*. The Linnean genus was based on a single species, *Plectronia ventosa* Linn.,⁴ the generic description being based on an actual specimen, except for the fruit and seed characters, which were taken from Burman. The specimen is an *Olinia*, and this single genus forms the family Oliniaceæ. Linnæus was in error in adding the fruit and seed characters from Burman and in adding to the species description the reference to "*Burm. afr.* 257, t. 94." which is *Plectronia* (*Canthium*) as currently interpreted. Apparently most botanists who have accepted *Plectronia* as the proper name of this rubiaceous genus interpreted it from the reference to Burman and did not critically scan the generic description which is unmistakably of *Olinia*. *Olinia* Thunberg (1799), unless it be protected by ultimate inclusion in some future list of *nomina conservanda*, will be replaced by *Plectronia* Linnæus (1767), and the family Oliniaceæ would have to be renamed.

The Philippine species described under *Plectronia* are here transferred to *Canthium*:

CANTHIUM BRUNNEUM (Merr.) comb. nov.

Plectronia brunnea MERR. in Philip. Journ. Sci. 17 (1920) 535; Enum.
Philip. Fl. Pl. 3 (1923) 535.

CANTHIUM CORDATUM (Merr.) comb. nov.

Plectronia cordata MERR. in Philip. Journ. Sci. 12 (1917) Bot. 166;
Enum. Philip. Fl. Pl. 3 (1923) 535.

⁴ Linnæus, C., Mantissa Plantarum 1 (1767) 6, 52.

CANTHIUM CULIONENSE (Elm.) comb. nov.

Lasianthus culionensis ELM., Leaf. Philip. Bot. 1 (1906) 11.

Plectronia culionensis MERR., Enum. Philip. Fl. Pl. 3 (1923) 535.

CANTHIUM DICOCCUM (Gaertn.) comb. nov.

Psydrax diococcus GAERTN., Fruct. 1 (1788) 125, t. 26.

Canthium didymum GAERTN. f., Fruct. 3 (1805) 94.

Plectronia didyma ELM., Leaf. Philip. Bot. 1 (1906) 28.

CANTHIUM ELLIPTICUM (Merr.) comb. nov.

Plectronia elliptica MERR. in Philip. Journ. Sci. 12 (1917) Bot. 165;
Enum. Philip. Fl. Pl. 3 (1923) 536.

CANTHIUM ELMERI nom. nov.

Plectronia gracilipes ELM., Leaf. Philip. Bot. 3 (1911) 1008; MERR.,
Enum. Philip. Fl. Pl. 3 (1923) 536, non *Plectronia gracilipes* Kurz
(1877), nec *Canthium gracilipes* Kurz (1872).

CANTHIUM FENICIS (Merr.) comb. nov.

Plectronia fenicis MERR. in Philip. Journ. Sci. 8 (1913) Bot. 50; Enum.
Philip. Fl. Pl. 3 (1923) 536.

CANTHIUM GLANDULOSUM (Blanco) comb. nov.

Ixora glandulosa BLANCO, Fl. Filip. (1837) 61.

Plectronia glandulosa MERR., Sp. Blancoanae (1918) 365; Enum.
Philip. Fl. Pl. 3 (1923) 536, cum syn.

CANTHIUM LEYTENSE (Merr.) comb. nov.

Plectronia leytensis MERR. in Philip. Journ. Sci. 8 (1913) Bot. 49;
Enum. Philip. Fl. Pl. 3 (1923) 537.

CANTHIUM MABESAE (Elm.) comb. nov.

Plectronia mabesae ELM., Leaf. Philip. Bot. 8 (1919) 3099; MERR.,
Enum. Philip. Fl. Pl. 3 (1923) 537.

CANTHIUM MEGACARPUM (Merr.) comb. nov.

Plectronia megacarpa MERR. in Philip. Journ. Sci. 4 (1909) Bot. 326;
Enum. Philip. Fl. Pl. 3 (1923) 537.

CANTHIUM MONSTROSUM (A. Rich.) comb. nov.

Plectronia monstrosa A. RICH., Mém. Rub. (1830) 109; MERR., Enum.
Philip. Fl. Pl. 3 (1923) 538, cum syn.

CANTHIUM OBOVATIFOLIUM (Merr.) comb. nov.

Plectronia obovatifolia MERR. in Philip. Journ. Sci. 12 (1917) Bot.
167.

CANTHIUM OLIGOPHLEBIUM (Merr.) comb. nov.

Plectronia oligophlebia MERR. in Philip. Journ. Sci. 17 (1920) 442;
Enum. Philip. Fl. Pl. 3 (1923) 538.

CANTHIUM PAUCINERVIUM (Merr.) comb. nov.

Plectronia paucinervia MERR. in Philip. Journ. Sci. 8 (1913) Bot. 51;
Enum. Philip. Fl. Pl. 3 (1923) 538.

CANTHIUM RAMOSII (Merr.) comb. nov.

Plectronia ramosii MERR. in Philip. Journ. Sci. 17 (1920) 443; Enum. Philip. Fl. Pl. 3 (1923) 539.

CANTHIUM SARCOCARPUM (Merr.) comb. nov.

Plectronia sarcocarpa MERR. in Philip. Journ. Sci. 10 (1915) Bot. 114.

CANTHIUM SUBCAPITATUM (Merr.) comb. nov.

Plectronia subcapitata MERR. in Philip. Journ. Sci. 17 (1920) 443; Enum. Philip. Fl. Pl. 3 (1923) 539.

CANTHIUM SUBSESSILIFOLIUM (Merr.) comb. nov.

Plectronia subsessilifolia MERR. in Philip. Journ. Sci. 12 (1917) Bot. 168.

CANTHIUM WENZELII (Merr.) comb. nov.

Plectronia wenzelii MERR. in Philip. Journ. Sci. 9 (1914) Bot. 387.

The remaining species have already been considered by various authors under *Canthium*. *Plectronia gynochthodes* Merr. becomes *Canthium gynochthodes* Baill., *Plectronia horrida* Benth. and Hook. f. becomes *Canthium horridum* Blume, and *Plectronia peduncularis* Vidal becomes *Canthium pedunculare* Cav.

TRICHURIASIS: RELATION BETWEEN THE NUMBER OF OVA PER GRAM OF FORMED STOOL AND THE NUMBER OF FEMALE WORMS HARBORED BY THE HOST

By C. MANALANG

Of the Philippine Health Service, Manila

This article deals with careful observations on a few clinical and autopsy cases previously studied for the purpose of determining the correlation between the number of hookworm ova per gram of formed stool and the number of female worms discharged by treatment or found at autopsy.

The egg-counting method and autopsy procedure are described in the two preceding articles in this series, on *Ancylostomiasis*.¹

The only point worthy of note is the fact that, due to the embedding of the thinner portion of the *Trichuris* in the mucosa, care was taken to remove all the worms from the cæcum even at the risk of leaving their slender portions. No adult parasites were ever found in the appendix, the ileum, or the transverse colon. The portion of stool removed in the morgue by puncture of the cæcum to make possible the counting of the eggs was examined well for adults, and a good many were thus found. The chance of losing *Trichuris* was much less than in the case of hookworms, because of their size and habitat.

The sex of the worms is easily distinguished by the naked eye, as the male has a spiral thick portion. Only one or two young worms were encountered. They were readily recognized due to the fact that they are small and white, while the adults resemble old ivory in color.

Table 1 shows four clinical cases of trichuriasis, with pre-treatment counts, number and sex of the worms removed, and posttreatment counts. The treatment was by means of chenopodium oil the method of administration of which has already been described. As in the previous studies, the egg counts per gram of stool were all reduced to "formed basis," using Stoll's

¹ Philip. Journ. Sci. 33 (1927) 35-65.

factor of 1, 2, and 4 for formed, mushy, and diarrhœal stools, respectively. No factor for the number of ova per gram per female was used, it being one of the objects of this study to determine such, if possible.

Since chenopodium does not expel *Trichuris* with certainty, the number of female worms recovered in the forty-eight-hour-treatment stools could not be said even to represent any known percentage of the total worms harbored; this could be determined better in the post-mortem cases. Experience has also taught that some worms might have been expelled after the forty-eight hours or not expelled at all. The only object in presenting Table 1 is to show the variability of the egg counts. Control counts were made four to five days after treatment. In case the patient failed to pass a stool in the second twenty-four hours, stools for the third twenty-four hours were saved.

CLINICAL CASES

Table 1 shows the protocols of four clinical cases.

Case 1, with 200 ova per gram before treatment, showed 2,025 per gram after treatment. Either worms were not expelled at all, or were expelled after forty-eight hours, but the discrepancy is apparent and cannot well be attributed to errors in counting.

Case 2 showed 2,100 ova per gram before treatment, and none after treatment. Here again the worms might have been passed after forty-eight hours.

Case 3 had 1,400 ova per gram, and treatment removed 7 males and 6 females. The control count showed 900 ova per gram, apparently only a slight diminution in the post-treatment egg count when some worms might have been passed after forty-eight hours.

Case 4 was almost the reverse of case 3, showing diminution from 900 ova per gram before treatment to 150 after treatment, which removed only one unclassified worm. Again, some might have been passed after forty-eight hours.

POST-MORTEM CASES

Tables 2 to 14 present the data from eighteen cadavers, showing sigmoidal or rectal counts in the first six cases (Table 2) and regional (ileal, cæcal, transversal, and sigmoidal or rectal) in the rest of the cases. In view of the nature of the causes of death of cases 8, 11, 17, and 18, they were classified as

normal controls. Due to absence of intestinal pathology in cases 2, 6, 7, 9, and 14, they could also be considered normal controls. Cases, 1, 3, 4, 5, 10, 12, 13, 15, and 16 all had intestinal pathology which might have influenced the females and their egg output or have produced mechanical hindrance or rapid deposition of the stools of the host during life. For the purpose of clearness the above classifications are designated as groups 1, 2, and 3, in which groups 1 and 2 are control cases and group 3 contains cases with intestinal pathology.

Considering control cases 7, 8, 9, 11, 14, 17, and 18 (cases of groups 1 and 2 counted regionally only) there were 31,625 ova in the cæcum, 12,750 ova in the transverse, and 10,275 ova in the sigmoid or rectum per gram of stool reduced to "formed basis." The total number of female worms recovered from these cases was 59; therefore, each female was represented by 536 ova per gram of stool in the cæcum, 216 ova in the transverse, and 174 in the sigmoid or rectum, with an average of 308 ova per gram of stool, "formed basis," for the three regions in the control cases and the cases without intestinal pathology.

When all the egg counts in the nine control cases (2, 6, 7, 8, 9, 11, 14, 17, and 18) without intestinal pathology (both regionally and sigmoidally counted cases) were added, there was a total of 58,550 ova from twenty-three regions. The number of females recovered from the cases counted regionally was multiplied by 3 while those counted sigmoidally were taken as counted. The total for the twenty-three regions was 188 female worms, or 311 ova per gram of stool per female, in the nine cases computed regionally and sigmoidally. The *Trichuris* egg factor per gram of stool, "formed basis," per female, may therefore be placed at around 310 in this series.

Cases with intestinal pathology, counted regionally (cases 10, 12, 13, 15, and 16), gave a total of 11,750 ova in the cæcum, 5,400 ova in the transverse, and 4,950 ova in the sigmoid or rectum, deposited by a total of 11 female worms, or 1,068 ova per gram per female in the cæcum, 491 in the transverse colon, and 450 in the sigmoid or rectum, with an average of 669 ova for all three regions.

It is evident that in the cases counted regionally, regardless of the condition of the alimentary tract, the number of *Trichuris* ova per gram of cæcal stool is higher than the number in either the transverse colon or the sigmoid. This is probably due to the parasitic concentration and fæcal stasis in the cæcum.

It is also apparent that the number of ova per gram of stool per female in the cases with intestinal pathology was about twice the number obtained in cases without intestinal pathology.

Examination of the tables will show marked variation between the number of ova per gram per female worm, considering the number of females found, and the number of ova per gram per female found when considered regionally; namely, from 50 ova per gram of stool per female in case 7 to 2,250 ova per gram of stool per female in case 14, both without intestinal pathology, and from 61 ova per gram of stool per female in case 3 to 8,392 ova per gram of stool per female in case 1, two cases with intestinal pathology. These figures were obtained by taking the average count for three regions surveyed (cæcum, transverse, and sigmoid) in each case dividing by the number of female worms recovered from the case.

Regionally, case 8, a rapid death by suicide, gave 679 ova per gram of stool per female in the cæcum, 121 ova in the transverse, and 208 ova per gram per female in the sigmoid.

Case 1 gave the high sigmoidal count of 8,392 ova per gram per female. A fæcal fistula was established about a week before death. This may be explained by the fact that the fistula drained well and, since no intestinal contents passed the obstruction and no normal stools passed per rectum during the time, the colon stool remained unmoved while the worms continued to lay eggs; unfortunately, regional counts were not made in this case. Proctoclysis was given. The females may have been good egg layers, or the fæcal stasis favored egg deposition.

Case 3, however, with fæcal fistula for two weeks and no normal stool per rectum since the date of operation (one month before death), did not show evidence of egg accumulation (61 ova per gram per female), which may have been prevented by the frequent enemas given. Even if a fæcal fistula had been present, there was no obstruction in the colon; so that very likely there was less stagnation in the colon. This may have been a case of poor egg-laying females or of unfavorable environment for egg laying.

Case 7 showed a rather low egg count (50 ova per gram per female, average for three regions counted), in the absence of intestinal pathology.

Two cases of typhoid fever (cases 4 and 12) with intestinal hæmorrhage gave similar egg counts (150) per gram of stool

per female; but case 10, also of typhoid fever with hæmorrhage, gave 1,875 ova for the sigmoid, 1,575 ova for the transverse, and 3,825 ova for the cæcum per gram of stool per female. This was another case of good egg-laying females. The presence of ova in the ileal content is explained by the large ulcerations on the ileocæcal valve, which permitted regurgitation of the cæcal content.

Case 14, with death from pneumococcic meningitis, showed 750 ova for the sigmoid, 1,050 ova for the transverse, and 4,950 ova for the cæcum per gram of stool from a single female recovered; this is another case of high egg production.

Case 16 (death following ptomain poisoning, with diarrhœa and vomiting, symptoms which were stopped by the administration of heavy doses of opiates forty-eight hours before death), clearly showed fewer ova—1,700 per gram in the cæcum, 300 ova per gram in the transverse, and none in the rectum. The decrease was probably due to diarrhœa.

Relatively high cæcal counts were evident in cases 8, 10, 11, 12, 13, 14, 16, 17, and 18 (75 per cent of all the cases counted regionally). In these nine cases were included all of group 1, normal controls (cases 8, 11, 17, and 18), one case without intestinal pathology (group 2, case 14), two cases of typhoid fever (cases 10 and 12), the case of amœbiasis (case 13), and the case of ptomain poisoning (case 16).

This high cæcal count could not have been due to volumetric variation in the stool, as the cæcum usually contained a considerable amount of stool. It was probably due to parasitic concentration, stasis, or a biological reaction of the female to the environment.

Relatively lower cæcal counts were observed in case 7 (pulmonary tuberculosis with hæmorrhage), case 9 (with beriberi), and case 15 (a violently insane American the autopsy findings on whom were meningeal and subdural hæmorrhage with about 2 kilograms of dry impacted stools in the colon).

In the light of the factor (310 ova per gram of stool per female *Trichuris*) obtained in groups 1 and 2 (cases of sudden death and deaths without intestinal pathology), the variations in the following cases are evident.

Case 1 (with the very high count of 8,392 ova per female found) and case 12 (with the relatively low count of 150 ova per female if only one was present, though not recovered) were

due to faecal stasis in the former, and to intestinal hæmorrhage in the latter, both mechanical factors. Case 3 (with repeated enemas) gave the low sigmoid count of 61 ova per gram per female.

Biological factors seem to have produced high counts in cases 10, 13, and 14; to these may be added case 1. Low count was evident in case 7. In spite of hæmorrhage from typhoid fever ulcers, case 10 gave 3,825, 1,575, and 1,875 ova per gram of stool per female in the cæcum, transverse, and sigmoid, respectively; the regurgitation of ova into the ileum has already been mentioned. The count for case 13 was apparently moderately high in the presence of amœbic ulcerations, while case 14, in the absence of intestinal pathology, with 4,950, 1,050, and 750 ova per gram of stool per female in the cæcum, transverse, and sigmoid, respectively, can be explained only by a high rate of egg production of the single female worm found.

In view of the highly resistant nature of the shell of the ova it is likely that ovulysis would not take place, though it is very peculiar that ova were not seen in the rectal stool of case 15, although ova were present in the cæcum and transverse. This case also failed to show hookworm ova in the rectal stool by the counting method, in spite of the 470 female worms found.

SUMMARY

1. *Trichuris* egg counts were made carefully on four clinical cases and eighteen fresh cadavers, previously studied under ancylostomiasis.

2. The clinical cases showed unreasonable variations between the pretreatment and the posttreatment counts.

3. Rectal or sigmoidal counts were made in six of the eighteen cadavers, and regional (ileum, cæcum, transverse, and rectum or sigmoid) in twelve.

4. The cases were classified into normal controls, or cases who died of violence, suddenly, or of some disease without intestinal pathology (nine cases), and pathological controls, or cases with intestinal pathology, either organic or functional (nine cases).

5. The *Trichuris* egg factor was found to be around 310 ova per gram of "random" stool, "formed basis," per female worm, for nine control cases, computed from twenty-three regions.

6. The average number of ova per gram of stool per female found for the cæcum, transverse, and sigmoid in cases with intestinal pathology was about twice that found in cases without intestinal pathology—669 in the former, and 310 in the latter.

7. Regardless of the condition of the alimentary tract, the number of ova per gram of stool in the cæcum per female worm was about equal to that in the transversal and sigmoidal stools combined.

8. Relatively high cæcal counts were evident in 75 per cent of all cases surveyed regionally. This was due probably to parasitic concentration, to fæcal stasis, or to biological reaction of the female to the environment. Based on the number of females found, marked variations in egg counts were observed between similar cases and between intestinal regions of the same case in both the normal and the pathological controls.

9. In one case of typhoid fever, *Trichuris* ova were found in the ileum owing to regurgitation of cæcal contents through a badly ulcerated ileocæcal valve.

10. In view of the highly resistant nature of the eggshell it is likely that ovoviviparity was not responsible for the low counts observed, though one case (15) seems to suggest this possibility.

11. The variations observed in the egg counts appeared to be influenced by mechanical and biological factors.

TABLE 1.—*Pretreatment and posttreatment egg counts in four cases of trichuriasis.*

Serial No. of patient.	Name.	Pretreatment egg count.			Parasites recovered.			Posttreatment egg count.		
		Type of stool.	Number of ova per gram.	Number of ova reduced to "formed basis."	Male.	Female.	Total.	Type of stool.	Number of ova per gram.	Number of ova reduced to "formed basis."
1.	V.J.	Mushy	100	200	0	0	0	Formed	2,025	2,025
2.	M.R.	do.	1,050	2,100	0	0	0	Mushy	0	0
3.	G.C.	Diarrhoeal	375	1,400	7	6	13	Formed	900	900
4.	T.V.	do.	225	900	(*)	(*)	9	do.	150	150

* Not classified.

TABLE 2.—*Showing sigmoidal or rectal egg counts in cases 1 to 6, inclusive.*

Serial No. of patient.	Name.	Type of stool.	Number of ova per gram in sigmoid or rectum.	Number of ova reduced to "formed basis."	Adult worms found.		Number of ova per female.	Remarks.
					Male.	Female.		
1.	M.A.	Formed	201,400	201,400	14	24	8,392	Autopsy findings, intestinal obstruction. Faecal fistula established one week before death. No stools per rectum.
2.	B.L.	do.	150	150	0	1	150	Broncho-pneumonia.
3.	C.F.	do.	675	675	5	11	61	Antemortem and post-mortem findings, lymphosarcoma of the jejunum and mesentery. Fistula spontaneously established at point of enterostomy. No intestinal obstruction.
4.	W.G.	Mushy	225	450	1	3	150	Typhoid fever with hemorrhage two days before death: stool black and mushy.
5.	G.F.	do.	300	600	3	3	200	Catarrhal enterocolitis.
6.	H.A.	do.	1,875	3,750	7	10	375	Autopsy findings, punctate hemorrhage in the brain, possibly due to ascariasis. Age of patient, 13 months; admitted suffering from convulsions.

TABLE 3.—*Showing egg counts in case 7, R.D.^a*

	Stool from—			Remarks.
	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	Autopsy findings, acute anæmia and asphyxia due to massive pulmonary hæmorrhage in chronic ulcerative and miliary tuberculosis of both lungs.
Ova per gram.....	0	75	75	
Ova, reduced to "formed basis"...	0	150	150	
Ova per female, by region.....	0	75	75	

^a Total parasites found, 2 males and 2 females.^b Mushy.TABLE 4.—*Showing egg counts in case 8, B.F.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Acute anæmia and hæmothorax with atelectasis of the left lung due to self-inflicted wound.
Ova per gram.....	0	21,050	3,750	6,450	
Ova, reduced to "formed basis"...	0	21,050	3,750	6,450	
Ova per female, by region.....	0	679	121	208	

^a Total parasites found, 34 males and 31 females.^b Mushy.^c Formed.TABLE 5.—*Showing egg counts in case 9, A.F.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Death due to pulmonary oedema and hydropleura, secondary to dilatation of beriberic heart.
Ova per gram.....	0	3,150	6,300	1,050	
Ova, reduced to "formed basis"...	0	3,150	6,300	1,050	
Ova per female, by region.....	0	315	630	105	

^a Total parasites found, 9 males and 10 females.^b Mushy.^c Formed.

TABLE 6.—*Showing egg counts in case 10, L.O.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Typhoid with intestinal hæmorrhage.
Ova per gram.....	100	3,825	1,575	1,875	
Ova, reduced to "formed basis" ..	400	7,650	3,150	3,750	
Ova per female, by region.....	200	3,825	1,575	1,875	

^a Total parasites found, 3 males and 2 females.^b Diarrhœal.^c Mushy.TABLE 7.—*Showing egg counts in case 11, P.C.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Acute anæmia due to postpartum hæmorrhage.
Ova per gram.....	0	450	450	300	
Ova, reduced to "formed basis" ..	0	450	450	300	
Ova per female, by region.....	0	150	150	100	

^a Total parasites found, 2 males and 3 females.^b Mushy.^c Formed.TABLE 8.—*Showing egg counts in case 12, P.S.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(b)	Typhoid fever with intestinal hæmorrhage.
Ova per gram.....	0	75	75	0	
Ova, reduced to "formed basis" ..	0	150	150	0	
Ova per female, by region.....	0	150	150	0	

^a Total parasites found, 3 males.^b Mushy.TABLE 9.—*Showing egg counts in case 13, A.S.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(b)	Amœbic abscess of the right lobe of the liver, extending into the right lung, and chronic ulcerative colitis.
Ova per gram.....	0	825	225	600	
Ova, reduced to "formed basis" ..	0	1,650	450	1,200	
Ova per female, by region.....	0	825	225	600	

^a Total parasites found, 1 male and 2 females.^b Mushy.

TABLE 10.—*Showing egg counts in case 14, L.I.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(c)	Suppurative leptomeningitis due to pneumococcus.
Ova per gram.....	0	2,475	525	750	
Ova, reduced to "formed basis".....	0	4,950	1,050	750	
Ova per female, by region.....	0	4,950	1,050	750	

^a One female parasite found.^b Mushy.^c Formed.TABLE 11.—*Showing egg counts in case 15, M.N.H.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Autopsy findings, meningeal congestion and œdema with subdural and meningeal hæmorrhage. A case of insanity. Colon packed with no less than 2 kilograms of dry stool in the form of balls, in the sigmoid and rectum.
Ova per gram.....	0	600	1,350	0	
Ova, reduced to "formed basis".....	0	600	1,350	0	
Ova per female, by region.....	0	150	340	0	

^a Total parasites found, 2 males and 4 females.^b Mushy.^c Formed.TABLE 12.—*Showing egg counts in case 16, V.F.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Acute gastroenterocolitis in ptomain poisoning. Diarrhœa and vomiting, stopped two days before death by opiates. Patient said to be demented.
Ova per gram.....	0	850	150	0	
Ova, reduced to "formed basis".....	0	1,700	300	0	
Ova per female, by region.....	0	566	100	0	

^a Total parasites found, 2 males and 3 females.^b Diarrhœal.^c Mushy.

TABLE 13.—*Showing egg counts in case 17, L.L.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Sudden death, due to cerebral hæmorrhage.
Ova per gram.....	0	1,425	450	1,425	
Ova, reduced to "formed basis".....	0	1,425	450	1,425	
Ova per female, by region.....	0	142	45	142	

^a Total parasites found, 7 males and 10 females.^b Mushy.^c Formed.TABLE 14.—*Showing egg counts in case 18, M.A.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(b)	Acute anæmia due to deep incised wound of the neck.
Ova per gram.....	0	300	300	75	
Ova, reduced to "formed basis.".....	0	600	600	150	
Ova per female, by region.....	0	300	300	75	

^a Two female parasites found.^b Mushy.

ASCARIASIS: RELATION BETWEEN THE NUMBER OF
OVA PER GRAM OF FORMED STOOL AND
THE NUMBER OF FEMALE WORMS
HARBORED BY THE HOST

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These observations were carefully made on clinical and autopsy cases studied previously under ancylostomiasis. The egg-counting method and autopsy procedure are described in the two articles in this series on ancylostomiasis.¹ Due to the migratory habits of *Ascaris*, attention in clinical cases was directed to the vomiting up of the parasites, and in the morgue the stomach, trachea, and œsophagus were examined. Due to the freshness and lightness of infection in the cadavers studied, migrations were not observed. Only adult female worms were considered in this study and they were identified by their large size and by the presence of ova in their uteri. The males were identified by the curved caudal end, their smaller size, and the spicules.

The clinical cases are submitted only for the purpose of showing the variability of egg counts. The number of worms recovered cannot be taken to represent any definite percentage of the total harbored. Many of the worms were expelled in the second twenty-four-hour stools; collection of forty-eight-hour-treatment stools was the rule, except when the patient passed no stool in the second twenty-four hours, in which case the third twenty-four-hour stools were collected. It was likely, therefore, that some worms were lost after the forty-eighth hour.

The treatment administered was oil of chenopodium, described in the first article on ancylostomiasis, and the control counts were made four to five days after the treatment.

One of the objects of these observations was to determine the *Ascaris* egg factor per gram of stool, "formed basis," per adult female worm.

Examination of the clinical cases (Table 1) shows that case 1, which discharged at least 1 adult female worm, showed no ova

¹ Philip. Journ. Sci. 33 (1927) 35-65.

in the pretreatment count. Very likely there were a few, though they were not encountered.

Case 6 had 4,800 pretreatment and 4,350 posttreatment ova per gram, "formed basis," in spite of the discharge of at least 7 adult worms (not classified as to sex); this suggests an apparent acceleration of egg production by the remaining females after treatment.

Case 9 showed 47,300 pretreatment and 47,025 posttreatment ova per gram of stool, in spite of the removal of 13 adult females by treatment. (Compare with case 6.)

Tables 2 to 9 show the data from the eleven autopsy cases, of which five (cases 2, 5, 6, 10, and 11) could be considered normal controls due to the absence of intestinal pathology, and 6 (cases 1, 3, 4, 7, 8, and 9), pathological controls.

The total number of ova in five control cases by region (seventeen regions) is 63,925. In cases 5, 6, 10, and 11 the total number of female worms found was multiplied by 4, because they were counted regionally. The total number of female worms thus computed for seventeen regions is 45, or about 1,420 ova per gram of stool, "formed basis," per female. This may be taken as the egg factor for this series of normal controls. By the same computation, cases 1, 3, 4, 7, 8, and 9 (cases with intestinal pathology) gave 24,800 ova and 17 female worms for fifteen regions, or 1,460 ova per gram of stool per female.

Using the *Ascaris* egg factor of 1,420, obtained in the series without intestinal pathology, the following points become evident in the cases studies: Cases 3, 4, and 7, which gave no egg counts, might be explained as due to the continuous elimination of the intestinal contents, hæmorrhage in typhoid in cases 3 and 7, and diarrhœa in a child (case 4), a mechanical cause of the disappearance of the ova. It is rather unlikely that ovoviviparity took place in the typhoid cases as the eggshell² is of a resistant nature, and in view of the opposite finding in case 8, also of typhoid fever. Biological factors seemed at work on cases 6, 8, 9, and 11 (with high counts) and on case 5 (with no count). That no ova were found in cases 3, 4, and 7 may also have been due to poor egg laying. Case 6, with 4,200, 3,400, 1,750, and 4,750 ova per gram of stool in the ileum, cæcum, transverse, and sigmoid, respectively, to the one female found, died a violent death. Case 11 also, whose counts were as high

² Manalang, C., Philip. Journ. Sci. 33 (1927) 249-255.

as those of case 6, died of violence. Cases 8 and 9 (even in the presence of typhoid fever with hæmorrhage in the former and ptomain poisoning in the latter) both showed high counts (see Tables 6 and 7). Case 2 (without intestinal pathology) gave only 325 ova per gram of rectal stool to the female. Case 5 (a case of ascariasis intoxication (?) in an infant) showed no ova in the rectal stool from the 2 adult females found. Case 10 showed 625, 637, 975, and 1,637 ova per gram of stool from the ileum, cæcum, transverse, and sigmoid, respectively, for every female found. This is possible evidence of dehydration of the stools containing even numbers of ova. Case 1 (with intestinal obstruction) gave a slightly higher count than normal.

SUMMARY

1. *Ascaris* egg counts were made on clinical and autopsy cases, in conjunction with hookworm studies.
2. Eleven clinical cases and eleven autopsy cases were studied and special care was taken not to lose any adult worms.
3. The clinical cases showed unreasonable discrepancies between pretreatment and posttreatment counts in some cases.
4. Of the eleven autopsy cases, five were cases without organic or evident functional pathology of the intestines, and six had pathologic alimentary tracts.
5. The egg factor per gram of stool, "random" specimen, reduced to "formed basis" per female, was found to be about 1,420 for the five normal cases, computed on seventeen intestinal regions.
6. Six cases with intestinal pathology gave an average of 1,460 ova per gram per female, computed on fifteen regions.
7. Mechanical and biological factors were apparently responsible for the variation of egg counts observed between cases and in the same case when the regions were analyzed in the light of the actual number of adult female worms found and of the egg factor.
8. Egg destruction in vivo cannot be considered a factor in producing variation in the number of ova in pathological controls due to the resistant nature of the shell.

TABLE 1.—Showing the data obtained from the eleven clinical cases.

Serial No. of patient.	Name.	Type of stool. ^a	Parasites recovered.			Ova reduced to "formed basis."	Ova per gram.	Type of stool.	Ova per gram.	Ova reduced to "formed basis."	Remarks.
			Male.	Female.	Total.						
1.-----	V.J.---	M	0	1	1	0	0	F	0	0	Very few eggs produced in an adult female worm.
2.-----	M.R.---	M	7,575	(b)	12	15,150	0	M	0	0	
3.-----	G.S.---	D	450	(b)	3	1,800	0	F	0	0	
4.-----	D.O.---	D	150	0	0	600	0	F	0	0	Worm may have been discharged after forty-eight hours, or retained but producing less ova after treatment.
5.-----	T.V.---	D	525	(b)	4	2,100	0	F	0	0	
6.-----	A.F.---	D	1,200	(b)	7	4,800	4,350	F	4,350	4,350	No decrease in egg count, in spite of the effect of the vermifuge.
7.-----	G.L.---	M	225	0	0	450	0	F	0	0	Worms either lost or there was decreased production of ova.
8.-----	A.T.---	M	1,200	5	7	2,400	(c)	(c)	(c)	(c)	
9.-----	L.S.---	F	47,300	3	15	47,300	47,025	F	47,025	47,025	No decrease in egg count, in spite of the effect of the vermifuge.
10.-----	E.G.---	D	375	0	1	1,500	10	F	10	0	
11.-----	D.R.---	D	2,175	1	4	8,700	0	F	0	0	

^a M, muhshy; D, diarrheal; F, formed.^b Not classified.^c Positive for ova not counted.

TABLE 2.—Showing egg counts in cases 1 to 4, inclusive.

Serial No. of patient.	Name.	Type of stool.	Ova per gram.	Ova reduced to "formed basis."	Parasites found.		Ova per gram per female.	Remarks.
					Male.	Female.		
1.....	M.A.	F	3,750	3,750	1	2	1,875	Cause of death, intestinal obstruction. Fæcal fistula one week before death.
2.....	B.L.	F	325	325	0	1	325	Broncho-pneumonia.
3.....	W.G.	M	0	0	3	2	(?)	Typhoid fever with intestinal hæmorrhage.
4.....	G.F.	M	0	0	0	1	(?)	Catarrhal enterocolitis in a child.

TABLE 3.—Showing egg counts in case 5, H.A.^a

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Autopsy findings, multiple punctate hæmorrhages in the brain with meningeal congestion and oedema, possibly due to ascariasis. Patient was a child of 13 months.
Ova per gram.....	0	0	0	0	
Ova per gram reduced to "formed basis".....	(?)	(?)	(?)	(?)	
Ova per female, by region.....	(?)	(?)	(?)	(?)	

^a Total parasites found, 4 males and 2 females.^b Mushy.^c Formed.TABLE 4.—Showing egg counts in case 6, B.F.^a

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Death due to acute anæmia and hæmorrhage, due to self-inflicted wound.
Ova per gram.....	2,100	3,400	1,750	4,750	
Ova per gram reduced to "formed basis".....	4,200	3,400	1,750	4,750	
Ova per female, by region.....	4,200	3,400	1,750	4,750	

^a Total parasites found, 1 male and 1 female.^b Mushy.^c Formed.

TABLE 5.—*Showing egg counts in case 7, L.O.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Typhoid fever with intestinal hæmorrhage.
Ova per gram.....	0	0	0	0	
Ova per gram reduced to "formed basis".....	(?)	(?)	(?)	(?)	
Ova per female, by region.....	(?)	(?)	(?)	(?)	

^a One female parasite found.^b Diarrhœal.^c Mushy.TABLE 6.—*Showing egg counts in case 8, P.S.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(b)	Typhoid fever with intestinal hæmorrhage.
Ova per gram.....	0	1,200	2,400	3,000	
Ova per gram, reduced to "formed basis".....	(?)	2,400	4,800	6,000	
Ova per female, by region.....	(?)	2,400	4,800	6,000	

^a Total parasites found, 1 male and 1 female.^b Mushy.TABLE 7.—*Showing egg counts in case 9, V.F.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Transverse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Ptomain poisoning. Diarrhœa stopped two days before death.
Ova per gram.....	150	1,650	1,675	300	
Ova per gram, reduced to "formed basis".....	600	3,300	3,350	600	
Ova per female, by region.....	600	3,350	3,350	600	

^a Total parasites found, 1 male and 1 female.^b Diarrhœal.^c Mushy.

TABLE 8.—*Showing egg counts in case 10, L.L.^a*

	Stool from—				Remarks.
	Ileum.	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(c)	(c)	(c)	Sudden death due to cerebral hæmorrhage in a case with arteriosclerosis, chronic interstitial nephritis, and hypertrophy of the left ventricle*
Ova per gram.....	1,875	3,825	5,850	9,825	
Ova per gram, reduced to "formed basis".....	3,750	3,825	5,850	9,825	
Ova per female, by region.....	625	637	975	1,637	

^a Total parasites found, 5 males and 6 females.^b Mushy.^c Formed.TABLE 9.—*Showing egg counts in case 11, M.A.^a*

	Stool from—				Remarks.
	Ileum-	Cæcum.	Trans-verse.	Sigmoid or rectum.	
Type of stool.....	(b)	(b)	(b)	(b)	Acute anæmia due to deep incised wound in the neck, severing the right jugular and carotid.
Ova per gram.....	2,625	2,175	2,550	5,775	
Ova per gram, reduced to "formed basis".....	5,250	4,350	5,100	11,550	
Ova per female, by region.....	2,625	2,175	2,550	5,775	

^a Total parasites found, 2 males and 2 females.^b Mushy.

THREE NEW PHILIPPINE FISHES

By ALBERT W. HERRE

Chief, Division of Fisheries, Bureau of Science, Manila

THREE PLATES

BELONIDÆ

TYLOSURUS PHILIPPINUS Herre, *sp. nov.*

Dorsal II-18 or 19; anal II-18 or 19 or I-20; pectoral 14 or 15; ventral 6; lateral line about $194 + 10$; about 22 scales between origin of dorsal and lateral line.

The compressed elongate body roughly pentagonal, head nearly triangular in cross section; depth 11.25 to 11.3 in length, breadth of body 1.56 to 1.6 in its own depth, which is greatest just before dorsal; head 2.88 to 2.93 in length, its flat upper surface with a wide, deep median channel and a small, narrow, elongate groove on each side of it; space between these and outer margin of interorbital with longitudinally divergent striæ; the median channel narrows abruptly anteriorly and is prolonged in a narrow median groove to tip of beak; the large lateral eye placed high up, 9 to 10 in head, 2.68 to 2.75 in postorbital part of head, 1.25 to 1.375 in interorbital, 6 to 6.25 in snout; the strong mandible 1.36 to 1.44 in head, extending beyond end of snout in a thick, spongy, somewhat flexible tip, which rises above so that upper jaw rests upon it and dorsal profile of latter is continuous with that of lower jaw tip when mouth is closed; upper margin of mandible, except its fleshy tip, in line with middle of pupil of eye; mouth abundantly supplied with long, strong, needle-pointed, vertical canines, those of lower jaw outside upper jaw when mouth is closed, tongue smooth except margin of posterior constricted part, which has some hard tubercles; fourth upper pharyngeals not distinct from third; maxillary not entirely hidden by preorbital; preopercle entirely covered with fine scales, opercle and top of head naked; pectorals broad, 3.3 to 3.5 in head; ventrals a little shorter than pectorals, more or less falciform; origin of dorsal opposite first undivided ray; anterior dorsal and anal rays elongate, equal to pectoral or a fourth longer, the dorsal rays longest in one specimen, the anal

rays in two specimens; dorsal height 3 to 3.2 times, anal 3.5 to 2.66 times in head; caudal peduncle short, its breadth 1.62 in its depth; the lateral line forms a very low but distinct whitish keel on caudal peduncle; caudal very badly damaged in the type specimens, about 2.5 in head, lower caudal lobe longer than upper one.

Color in alcohol brownish above, silvery below, opercles and underside of head white. Fins colorless except upper half of dorsal, which is dusky.

Here described from the type, No. 11,084 Bureau of Science collection, 452 millimeters long, and the cotype, 462 millimeters long, collected at Coron, Busuanga. I also have a specimen, 435 millimeters long, from Tandubas Island and one, 390 millimeters long, from Sitankai, both in Sulu Province. I have compared these fishes with all the material in the United States National Museum and at Stanford University and find nothing there like them. The singular beak almost warrants the creation of a new genus for them. The cartilaginous tip is apparently a sense organ similar to that at the tip of a *Hemiramphus* beak.

Philippinus, from the Philippines.

BRANCHIOSTEGIDÆ

BRANCHIOSTEGUS ILOCANUS Herre, sp. nov.

Dorsal VII-14, first and second spines united; anal II-11; lateral line about 60; scales in transverse series 25.

The head and the tapering body flattened laterally, much thicker anteriorly, depth 3.6 in length; the large head thicker than trunk, 2.96 in total; head almost flat above, profile rounded as it descends over eye, snout very steep; dorsal profile straight and slightly descending from above head to caudal peduncle; anterior half of ventral line nearly straight, then curving upward to caudal peduncle; the very large lateral eye high up, the distance from its front margin to tip of snout approximately equal to distance from its rear margin to posterior extremity of opercle, 4.55 in head and 1.95 in the large prominent snout, which is 2.33 in head; interorbital very slightly exceeds eye in breadth, 4.33 in head, a longitudinal groove along its middle; cheek very broad, its depth approximately equal to snout; the oblique mouth rather large, lower jaw included, posterior extremity of maxillary reaching a vertical midway between posterior nostril and anterior margin of eye; teeth of upper jaw in two rows except anteriorly, where they are in four rows;

teeth of outer row much larger and stronger than the others, the last two teeth on each side hooked canines; teeth of lower jaw in one row except at symphysis, where they are in three rows: no reduced teeth in lower jaw, but those along middle of each side enlarged; 8 rows of scales on cheek, the three middle rows of enlarged scales; posterior margin of preopercle denticulate; scales extending forward on head to anterior portion of interorbital; body scaled everywhere, and fine scales extend on pectoral and more than half the length of caudal; no scales on suborbital, snout, jaws, and underside of head.

Origin of dorsal above pectoral base, first spine three-fourths of an eye diameter, second spine 1.5 times eye, the remaining spines and rays very gradually increasing until the next to the last, which is 2.65 times eye or a trifle more than 1.7 in head; anal resembles dorsal, the last few rays about equal, 1.75 times eye or 2.6 in head; depth of caudal peduncle 3 in head; caudal subtruncate, the uppermost rays longest, 1.44 in head or 4.28 in length; pectoral pointed, the central rays elongate, 1.33 times in head or 3.97 in length; the ray next below the longest, or seventh ray, not abruptly shortened as described by Snyder for *B. japonicus*; the narrow pointed ventrals fall far short of anus, 2 + times in head, 6 in length.

Color in alcohol dusky olive brown on top of head and along back, the sides and belly silvery; a black seam extends forward from base of dorsal to anterior extremity of interorbital space; suborbital and snout bright yellow, with a triangular orange spot on lower median portion of snout; a yellow band on base of dorsal, now almost entirely disappeared; a fine blackish marginal line on dorsal and upper margin of pectoral; anal, pectoral, and ventral colorless; an olive brown triangle covers lower third of caudal, its apex at lower side of caudal peduncle; a central longitudinal band of the same color, and a marginal line of olive brown above; remainder of fin yellowish.

Here described from a specimen, 270 millimeters long, purchased in the market at Narvacan, Ilocos Sur Province, Luzon. *Ilocanus*, from Ilocos.

CALLIONYMIDÆ

SYNCHIROPUS TENTACULATUS Herre, sp. nov.

Dorsal IV-8; anal 7.

Body rounded, wedge-shaped, with wide head and slender snout, depth 5.3 to 5.5 in length; head a third to a half wider

than deep, wider than body, 2.9 to 3.1 in length; the large dorso-lateral eyes surrounded, except below, by a bony rim, prominent anteriorly, 3 to 3.25 in head; in females the concave snout scarcely equals eye; in males the snout is longer, 2.75 in head; mouth terminal, upper jaw protractile, posterior extremity of maxillary not extending to anterior margin of eye; the narrow interorbital 5 to 6 in eye; the preopercle has a strong, backward-projecting spine, a little shorter than eye, with a spine on inner side near its tip and a small downward-projecting spine farther forward on its outer side; a threadlike tentacle on each eye, just inside upper posterior margin, its length nearly equal to an eye diameter; two circular bony plates covered with tooth-like asperities on occipital region, each half an eye diameter; first dorsal low, first spine highest, 2.5 in head in females, 1.85 in males; second dorsal very little higher than first in the female, first and second rays longest, 2.2 in head; in the male the anterior dorsal rays high, the others successively shorter except the last which is a little the longest, 1.57 in head, extending to base of caudal; anal like second dorsal, but scarcely as high in the female; in the male anal low except the last two rays which are much elongated, extending upon caudal, 1.22 in head; the narrow subtruncate caudal slightly exceeds head in the female, 2.66 in length; it is much longer in the male, more than half again as long as head, 1.9 times in length; the broad ventrals longer than pectorals, extending to or beyond origin of anal, equal to head in the male, a tenth shorter in the female, the outer rays less than half the length of the inner ones; central rays of pectoral much longer than the others, forming a pointed lobe extending beyond origin of anal, 1.5 in head in the female, 1.37 in the male; a slender pointed anal papilla present in the male.

Color in alcohol dark wine red with purplish luster, snout paler, belly whitish; tentacle wine red; spinous dorsal pale wine red, soft dorsal much paler; anal with two longitudinal rows of dusky or dark brown spots on outer half; caudal with three transverse rows of black spots in the male, brown in the female, the lower ray with several dark spots; male with sides of snout, cheeks, eye, upper side of ventrals, basal half of pectorals, and basal portion of caudal with beautiful irregular pearl-colored spots; both male and female have the upper side of ventrals red like body, with several circular black dots sprinkled on it; pectorals brown, with many obscure crossbars.

Here described from the type, No. 7302 Bureau of Science collection, a male, 34.5 millimeters long, the caudal 18 millimeters long, and a female cotype, 32 millimeters long. Both were obtained at Puerto Galera, Mindoro, by Alvin Seale, in May, 1912.

I can find no record in the accessible literature of a callionymid fish with tentacles upon its eyes. This seems to be a unique character in this group.

Tentaculatus, having tentacles.

ILLUSTRATIONS

PLATE 1

Synchiropus tentaculatus sp. nov., male. (Drawing by José L. Nievera.)

PLATE 2

FIG. 1. *Tylosurus philippinus* sp. nov.; $\times \frac{1}{2}$. (Drawing by P. Bravo.)

2. *Tylosurus philippinus* sp. nov.; $\times 1\frac{1}{2}$. (Drawing by P. Bravo.)

PLATE 3

Branchiostegus ilocanus sp. nov. (Drawing by José L. Nievera.)



PLATE 1. SYNCHIROPUS TENTACULATUS SP. NOV., MALE.

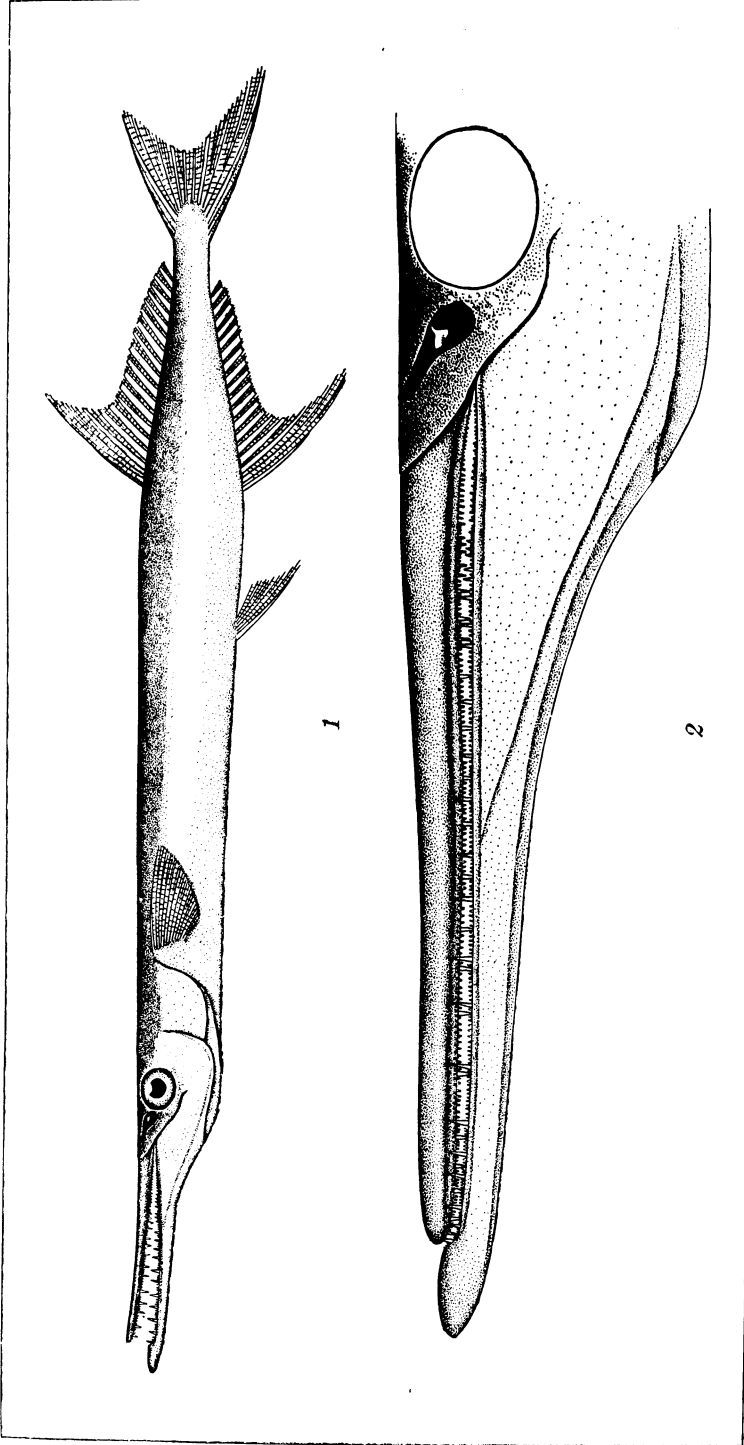


PLATE 2. TYLOSURUS PHILIPPINUS SP. NOV.

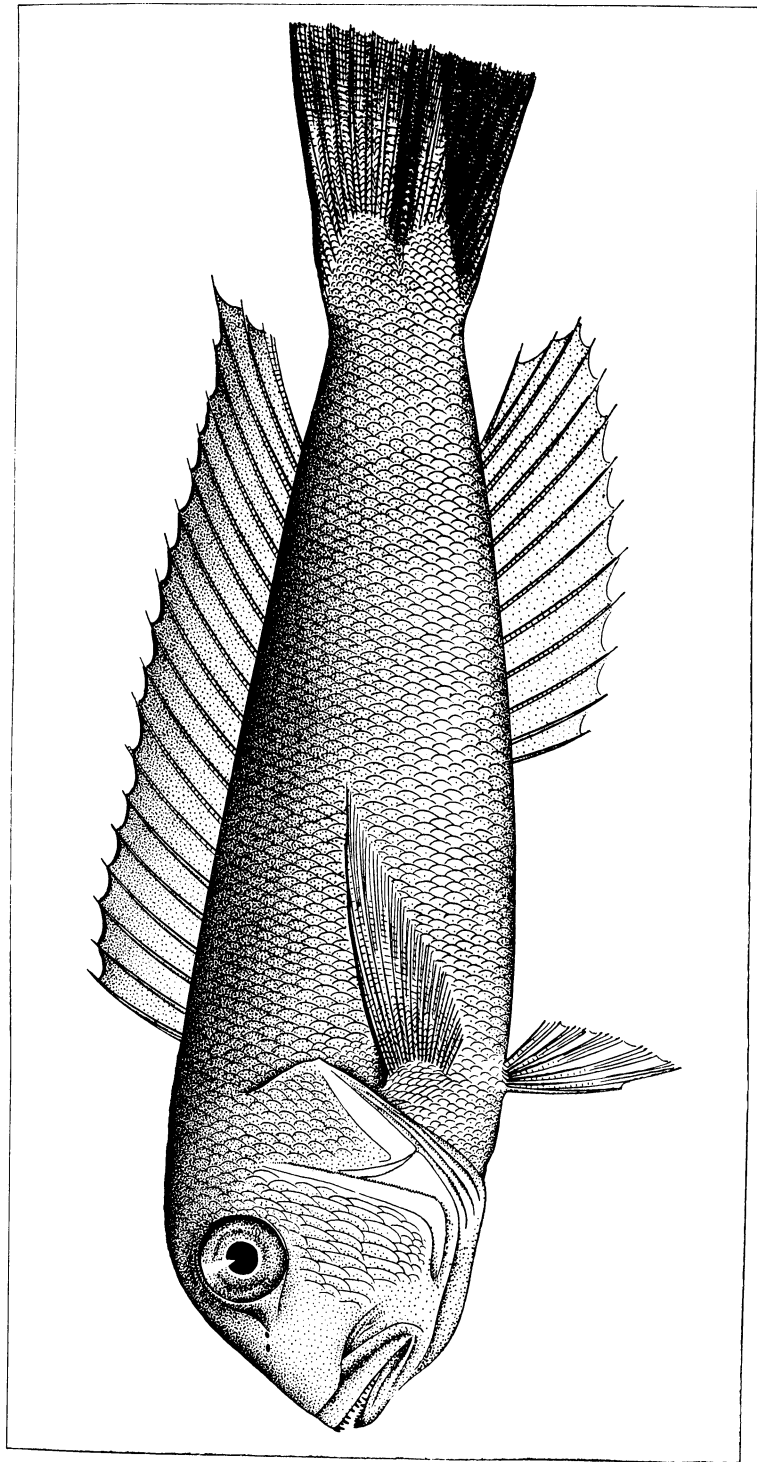


PLATE 3. BRANCHIOSTEGUS ILOCANUS SP. NOV.

DIATOMS FROM KHINGAN, NORTH MANCHURIA, CHINA

By B. W. SKVORTZOW
Of Harbin, Manchuria

FIVE PLATES

During my visit to the western part of North Manchuria in 1922, I made some collections of diatoms in Khingan Mountains in the environs of the Fuleierdi Railway Station. One of all samples was gathered in a small stream among the *Fontinalis* sp. stems and inspection of it yielded a considerable number of forms, of which I give here an enumeration, that may serve as a contribution to the history of the geographical distribution of these small organisms.

Very little attention has until recently been bestowed upon diatoms of Manchuria. They are listed in two of my notes which appeared during the last two years.¹ In the present paper I give the figures of nearly all forms listed here, some of which seem to be new to science.

Among those of special interest may be noted *Fragilaria hinganensis* sp. nov.; a species allied to *F. capucina* Desmazieres, *Frustulia vulgaris* Thw. var. *asiatica* var. nov., *Pinnularia episcopalıs* Cleve var. *manschurica* var. nov.

The forms of diatoms found in the collection are herein enumerated.

MELOSIRA VARIANS Agerth. Plate 1, fig. 1.

Frustules cylindrical, in long filaments, slightly constricted on each side of the suture. Length, 0.025 millimeters; breadth, 0.050.

MELOSIRA DISTANS Kützıng. Plate 1, fig. 2.

Frustules cylindrical. Puncta in longitudinal rows. Length, 0.038 to 0.035 millimeter; breadth, 0.0051 to 0.0187.

¹ Beiträge zur Kenntnis der Mandschurischen Diatomaceen, Nuova Notarısia Ser. XXXVI (1925), and Ueber einige Süßwasseralgen aus der Nord Mandschurei im Jahre 1916 gesammelt, Archiv für Hydrobiologie, No. 3 16 (1926).

MELOSIRA ITALICA Kützing. Plate 1, figs. 3, 4.

Frustules cylindrical. Puncta in spiral rows. Length, 0.025 to 0.0359 millimeter; breadth, to 0.006. Margins of valves denticulate at the junction of the frustules.

MELOSIRA ITALICA var. **GENUINA** forma **TENUIS** (Kützing) O. Müller. Plate 1, fig. 5.

Frustules, 0.005 millimeter in breadth.

TABELLARIA FLOCCULOSA Kützing. Plate 1, fig. 6.

Valve linear, with median inflation larger than terminal. In zone view the frustules are quadrangular. Length, 0.035 millimeter; breadth, 0.009.

TABELLARIA FENESTRATA (Lyngb.) Kützing. Plate 1, fig. 7.

Valve elongated; pseudoraphe narrow. Length, 0.0745 millimeter; breadth, 0.006.

MERIDION CONSTRICTUM Ralfs. Plate 1, fig. 8.

Valve with a capitate end. Length, 0.0323 millimeter; breadth, 0.0042. Striæ, 5 in 0.01 millimeter.

MERIDION CIRCULARE Agarth. Plate 1, fig. 9.

Frustules in zone view cuneate, adnate in circular or spiral fasciæ. Length, to 0.0493 millimeter; breadth, to 0.004. Striæ, 3 to 4 in 0.01 millimeter.

FRAGILARIA HINGANENSIS sp. nov. Plate 1, figs. 10 to 15.

Valve linear, apices slightly produced and subrostrate. Length, 0.0255 to 0.0655 millimeter; breadth, 0.0034. Zone view breadth, 0.0042 to 0.0068 millimeter. Striæ, 24 in 0.01 millimeter.

Found in long ribbon or fasciæ.

FRAGILARIA HINGANENSIS var. **LONGISSIMA** var. nov. Plate 1, figs. 16, 17.

Valve linear with subrostrate ends. Length, 0.085 to 0.136 millimeter; breadth, 0.0034. Zone view, 0.0051 to 0.0076 millimeter. Striæ, 24 in 0.01 millimeter.

Found in long ribbons.

SYNEDRA ULNA Ehrenberg. Plate 1, fig. 18.

Valve linear lanceolate, with rostrate apices. Interrupted in the middle. Length, 0.140 millimeter; breadth, 0.0068. Striæ, 9 in 0.01 millimeter.

SYNEDRA ULNA var. **DANICA** Kützing. Plate 1, figs. 19, 20.

Valve solitary or in twos, linear with rostrate apices. Length, 0.217 to 0.3589 millimeter; breadth, 0.0042. Striæ, 0.009 in 0.01 millimeter.

SYNEDRA ULNA var. **AMPHIRRHYNCHUS** Ehrenberg. Plate 1, figs. 21, 22.

Valve linear, with slightly capitate ends. Length, 0.238 millimeter; breadth, 0.006. Striæ, 9 in 0.01 millimeter.

SYNEDRA ULNA var. **OXYRRHYNCHUS** Kützing. Plate 1, fig. 23.

Valve small linear, lanceolate with rostrate apices. Striæ not interrupted in the middle. Length, 0.085 millimeter; breadth, 0.0075. Striæ, 9 in 0.01 millimeter.

SYNEDRA ACUS Kützing var. **DELICATISSIMA** W. Smith. Plate 1, figs. 24, 25.

Valve free linear, lanceolate, slightly rostrate at the end. Length, 0.0731 to 0.1227 millimeter; breadth, 0.0028 to 0.003. Striæ 11 to 15 in 0.01 millimeter.

SYNEDRA ACUS var. **ANGUSTISSIMA** Grunow. Plate 1, fig. 26.

Valve free, lanceolate. Length, 0.170 millimeter; breadth, 0.0042. Striæ, 16 in 0.01 millimeter. Rare.

EUNOTIA PECTINALIS Kützing var. **VENTRICOSA** Grunow. Plate 2, fig. 1.

Valve tumid in the middle. Length, 0.0724 millimeter; breadth, 0.0055. Striæ 9 in 0.01 millimeter.

EUNOTIA PECTINALIS var. **IMPRESSA** O. Müller. Plate 2, fig. 2.

Valve with two undulations. Length, 0.0444 millimeter; breadth, 0.005. Striæ, 12 in 0.01 millimeter.

EUNOTIA PECTINALIS var. **IMPRESSA** forma **CURTA** Van Heurck. Plate 2, fig. 3.

Valve short, slightly curvate. Length, 0.0238 to 0.0255 millimeter; breadth, 0.0051. Striæ, 12 or 13 in 0.01 millimeter.

EUNOTIA LUNARIS Ehrenberg. Plate 2, figs. 4, 5.

Frustules sessile, solitary or in clusters. Valve arcuate, narrow, attenuated toward the apices, which are sometimes slightly rostrate or rostrate-capitate. Length, 0.0544 to 0.0867 millimeter; breadth, 0.0034 to 0.0036. Striæ, 12 in 0.01 millimeter.

COCCONEIS PLACENTULA Ehrenberg.

Valve elliptical; with a lanceolate axial area, radiating rows of puncta, and a wide border of finely punctate, radiating striæ, separated from the central part of the valve by a narrow hyaline zone. Length, 0.0187 to 0.0238 millimeter; breadth, 0.0102 to 0.0119.

DIPLONEIS PUELLA (Schum.) Cleve. Plate 2, fig. 6.

Valve elliptical. Length, 0.0221 millimeter; breadth, 0.012. Costæ, 14 or 15 in 0.01 millimeter.

NEIDIUM IRIDIS Ehrenberg. Plate 2, fig. 7.

Valve linear subelliptical, with rounded ends. Length, 0.136 millimeter; breadth, 0.0221. Striæ, 16 to 18 in 0.01 millimeter.

NEIDIUM IRIDIS var. **AMPLIATA** Ehrenberg. Plate 2, fig. 8.

Valve broadly elliptical, with subrostrate ends. Length, 0.0811 millimeter; breadth, 0.025. Striæ, 16 in 0.01 millimeter.

NEIDIUM IRIDIS var. **FIRMA** V. Heurck. Plate 2, fig. 9.

Valve linear. Length, 0.1037 millimeter; breadth, 0.0272. Striæ, 16 or 17 in 0.01 millimeter; puncta, 18 in 0.01 millimeter.

NEIDIUM AFFINE Ehrenberg var. **GENUINA** Cleve forma **MEDIA** Cleve. Plate 2, fig. 10.

Valve linear, with rostrate ends. Length, 0.128 millimeter; breadth, 0.0272. Striæ, 20 in 0.01 millimeter.

NEIDIUM AFFINE var. **AMPHIRHYNCHUS** Ehrenberg forma **MANSCHURICA** forma nova. Plate 2, fig. 11.

Valve with protracted, rostrate-capitate ends. Length, 0.0833 millimeter; breadth, 0.0255. Striæ, 24 in 0.01 millimeter.

FRUSTULIA VULGARIS Thwaites var. **ASIATICA** var. nov. Plate 2, fig. 12.

Valve lanceolate, with obtuse rounded ends. Length, 0.0527 millimeter; breadth, 0.0085. Striæ, 23 in 0.01 millimeter.

NAVICULA BACILLIFORMIS Grunow. Plate 2, fig. 13.

Valve linear, with broad, rounded ends. Length, 0.034 millimeter; breadth, 0.0102. Central area rectangular. Striæ, 15 to 17 in 0.01 millimeter.

NAVICULA RADIOSA Kützing var. **MANSCHURICA** var. nov. Plate 2, fig. 14.

Valve linear, obtuse. Length, 0.0766 millimeter; breadth, 0.008. Striæ, 9 in 0.01 millimeter, in the middle slightly radiate, elsewhere almost parallel.

NAVICULA PEREGRINA Ehrenberg. Plate 2, fig. 15.

Valve lanceolate, with obtuse ends. Length, 0.0901 millimeter; breadth, 0.017. Central area large. Striæ, 6 to 7 in 0.01 millimeter.

NAVICULA REINHARDII Grunow. Plate 2, fig. 16.

Valve elliptical, with broad obtuse ends. Length, 0.0731 millimeter; breadth, 0.017. Striæ, 8 in 0.01 millimeter.

NAVICULA CINCTA Ehrenberg var. **LEPTOCEPHALA** Ehrenberg. Plate 2, fig. 17.

Valve lanceolate, with slightly rostrate and obtuse ends. Length, 0.034 millimeter; breadth, 0.0069. Striæ, 9 in 0.01 millimeter.

NAVICULA sp. Plate 2, fig. 18.

Valve lanceolate, with rostrate and obtuse ends. Length, 0.039 millimeter; breadth, 0.0085. Striæ, 18 in 0.01 millimeter.

NAVICULA AMPHIBOLA Cleve var. MANSCHURICA var. nov. Plate 2, fig. 19.

Valve elliptic-lanceolate, with rostrate, truncate ends. Length, 0.0459 millimeter; breadth, 0.017. Central area rectangular. Striæ, 13 to 15 in 0.01 millimeter.

PINNULARIA MESOLEPTA Ehrenberg var. STAURONEIFORMIS Grunow. Plate 2, fig. 20.

Valve triundulated, with capitate ends. Length, 0.0663 millimeter; breadth, 0.0136. Striæ, 8 or 9 in 0.01 millimeter, strongly divergent in the middle and convergent at the ends.

PINNULARIA BREISSONI Kützing var. DIMINUTA V. Heurck. Plate 2, fig. 21.

Valve linear-elliptical, with rounded ends. Length, 0.0272 millimeter; breadth, 0.0076. Area narrow. Striæ 16 in 0.01 millimeter, divergent in the middle and convergent toward the ends.

PINNULARIA NODOSA Ehrenberg var.? Plate 2, fig. 22.

Valve linear, with slightly triundulate margins, with rostrate ends. Length, 0.0663 millimeter; breadth, 0.0102. Median line filiform. Axial area wider than one-third of the breadth of the valve. Striæ, 8 in 0.01 millimeter, interrupted, divergent in the middle, convergent at the ends.

PINNULARIA LEGUMEN Ehrenberg. Plate 2, fig. 23.

Valve linear-lanceolate, with slightly triundulate margins and subrostrate, broad ends. Length, 0.0731 millimeter; breadth, 0.0102. Axial area broad, dilated in the middle. Striæ, 10 in 0.01 millimeter, divergent in the middle, convergent at the ends.

PINNULARIA EPISCOPALIS Cleve var. MANSCHURICA var. nov. Plate 3, figs. 1, 2.

Valve linear, with parallel margins or slightly gibbous in the middle. The ends broadly rounded. Length, 0.1571 to 0.289 millimeter; breadth, 0.033 to 0.0444. Striæ, 6 or 7 in 0.01 millimeter, strongly divergent in the middle and convergent at the ends.

PINNULARIA MAJOR Kützing. Plate 3, fig. 3.

Valve slender, linear, gibbous in the middle, and rounded at the ends. Length, 0.177 to 0.203 millimeter; breadth, 0.0255. Striæ, 6 or 7 in 0.01 millimeter.

PINNULARIA MAJOR forma MANSCHURICA forma nova. Plate 3, fig. 4.

Valve linear, slightly gibbous in the middle. Length, 0.150 to 0.159 millimeter; breadth, 0.020 to 0.0204. Striæ, 6 or 7 in 0.01 millimeter.

PINNULARIA VIRIDIS Nitzsch. Plate 3, fig. 5.

Valve elliptic-linear, with parallel margins. Length, 0.111 to 0.1139 millimeter; breadth, 0.0187 to 0.0204. Striæ, 6 or 7 in 0.01 millimeter, slightly divergent in the middle and convergent at the ends.

PINNULARIA VIRIDIS var. **INTERMEDIA** Cleve. Plate 3, fig. 6.

Valve linear, with parallel margins, attenuated toward the rounded ends. Length, 0.0629 millimeter; breadth, 0.012. Striæ, 8 in 0.01 millimeter, divergent in the middle, convergent at the ends.

PINNULARIA NOBILIS Ehrenberg var. **INTERMEDIA** Dippel. Plate 3, fig. 7.

Valve linear, slightly gibbous in the middle and at the broadly rounded ends. Length, 0.240 millimeter; breadth, 0.0296. Median line complex. Striæ, 5 or 6 in 0.01 millimeter, divergent in the middle, convergent at the ends.

PINNULARIA NOBILIS var. **MANSCHURICA** var. nov. Plate 3, fig. 8.

Valve linear, with parallel margins and broadly rounded ends. Length, 0.374 millimeter; breadth, 0.0425. Median line complex. Axial area broad. Striæ, 5 or 6 in 0.01 millimeter, divergent in the middle, convergent at the ends.

PLEUROSTAURON ACUTA W. Smith. Plate 2, fig. 24.

Valve rhombic-lanceolate, gradually tapering from the middle to the narrow obtuse ends. Length, 0.136 millimeter; breadth, 0.0238. Striæ, 11 or 12 in 0.01 millimeter.

STAURONEIS PHOENICENTERON Ehrenberg var. **GENUINA** Cleve forma. Plate 2, fig. 25.

Valve lanceolate, with obtuse ends. Length, 0.1479 millimeter; breadth, 0.0323. Stauros not reaching to the margin. Striæ radiate throughout, 13 or 14 in 0.01 millimeter, distinctly punctate.

STAURONEIS PHOENICENTERON var. **GENUINA** Cleve. Plate 2, fig. 26.

Valve lanceolate, with obtuse ends. Length, 0.1496 millimeter; breadth, 0.0272. Stauros linear, reaching the margin. Striæ, 12 or 13 in 0.01 millimeter.

STAURONEIS PHOENICENTERON var. **AMPHILEPTA** Ehrenberg. Plate 2, fig. 27.

Length, 0.0935 millimeter; breadth, 0.007. Stauros linear. Striæ, 18 in 0.01 millimeter.

STAURONEIS PHOENICENTERON var. **VULGARIS** Dippel forma **INTERMEDIA** Dippel. Plate 2, fig. 28.

Valve lanceolate, with slightly capitate ends. Length, 0.0918 millimeter; breadth, 0.0187. Striæ, 15 to 17 in 0.01 millimeter.

GOMPHONEMA ACUMINATUM Ehrenberg var. **CORONATA** Ehrenberg. Plate 2, fig. 29.

Valve clavate, biconstricted, with broad, apiculate apex. Length, 0.0544 millimeter; breadth, 0.0153. Striæ, 10 in 0.01 millimeter.

GOMPHONEMA ACUMINATUM var. **BREBISSEI** Kützing. Plate 2, figs. 30, 31.

Valve slightly biconstricted, with cuneate apex. Length, 0.0306 to 0.0476 millimeter; breadth, 0.0068 to 0.0085. Striæ, 9 or 10 in 0.01 millimeter.

GOMPHONEMA ACUMINATUM var. **TRIGONOCEPHALA** Ehrenberg. Plate 2, fig. 32.

Valve not distinctly biconstricted. Apex cuneate. Length, 0.0255 millimeter; breadth, 0.0068. Striæ, 10 or 11 in 0.01 millimeter.

GOMPHONEMA PARVULUM Kützing var. **MICROPUS** Kützing. Plate 3, fig. 9.

Valve slightly clavate, lanceolate, with obtuse apex and subacute basis. Length, 0.0153 millimeter; breadth, 0.0051. Striæ, 11 in 0.01 millimeter.

GOMPHONEMA CONSTRICTUM Ehrenberg var. **CAPITATA** Ehrenberg. Plate 3, fig. 10.

Valve very slightly constricted, clavate with broad apex. Length, 0.0326 millimeter; breadth, 0.012. Striæ, 9 in 0.01 millimeter.

GOMPHONEMA CONSTRICTUM forma **CURTA** Grunow. Plate 3, fig. 11.

Valve length, 0.030 millimeter; breadth, 0.012. Striæ, 9 in 0.01 millimeter.

GOMPHONEMA SPHAEROPHORUM Ehrenberg. Plate 3, fig. 12.

Valve clavate, with capitate apex and narrow basis. Length, 0.0391 millimeter; breadth, 0.0085. Central area small. Striæ, 10 in 0.01 millimeter.

GOMPHONEMA GEMINATUM Lyngb. Plate 2, figs. 13, 14.

Valve strongly biconstricted, with broad, subtruncate apex and basis. Length, 0.1185 to 0.1258 millimeter. Central area with two to five stigmas, disposed in a longitudinal row on one side of the central nodule. Striæ, 8 in 0.01 millimeter.

CYMBELLA ASPERA Ehrenberg. Plate 4, figs. 1, 2.

Valve broad, with strongly arcuate dorsal margin, and straight, centrally gibbous ventral margin. Ends obtuse, rounded. Length, 0.148 to 0.180 millimeter; breadth, 0.030 to 0.035. Median line arcuate. Axial area linear, slightly dilated in the middle. Striæ in the middle, 8 in 0.01 millimeter, slightly radiate, punctate; puncta, 12 to 15 in 0.01 millimeter, in the end, 9 to 11 in 0.01 millimeter.

CYMBELLA ASPERA var. **ELONGATA** var. nov. Plate 4, fig. 4.

Valve length, 0.192 to 0.340 millimeter; breadth, 0.037 to 0.045. Striæ, 8 or 9 in 0.01 millimeter. Puncta, 12 to 15 in 0.01 millimeter.

CYMBELLA ASPERA var. **MANSCHURICA** var. nov. Plate 4, fig. 5.

Valve length, 0.114 to 0.325 millimeter; breadth, 0.0259 to 0.0444. Median line arcuate. Axial area linear, slightly dilated in the middle. Striæ in the middle, 7 to 9 in 0.01 millimeter; in the end, 9 to 10 in 0.01 millimeter. Puncta 7 to 10 in 0.01 millimeter.

CYMBELLA CUSPIDATA Kützing. Plate 3, figs. 15, 20.

Valve broadly linear-lanceolate, with rostrate-capitate ends. Length, 0.0408 to 0.0969 millimeter; breadth, 0.0153 to 0.0306. Striæ, 8 to 10 in 0.01 millimeter.

CYMBELLA HETEROPLEURA Ehrenberg. Plate 5, fig. 1.

Valve broadly linear lanceolate, slightly asymmetrical with rostrate ends. Length, 0.136 millimeter; breadth, 0.0323. Central area large. Striæ, 7 or 8 in 0.01 millimeter. Puncta, 15 in 0.01 millimeter.

CYMBELLA TUMIDA Brebisson var. **BOREALIS** Grunow. Plate 5, fig. 2.

Valve boat-shaped, with slightly gibbous ventral margin. Ends obliquely truncate, not rostrate. Length, 0.0731 millimeter; breadth, 0.0221. Striæ, 9 in 0.01 millimeter.

CYMBELLA CISTULA Hemprich. Plate 5, fig. 3.

Valve boat-shaped, with concave, slightly gibbous ventral margin and rounded obtuse ends. Length, 0.0799 to 0.0935 millimeter; breadth, 0.0221. Striæ, 7 in 0.01 millimeter. A distinct row of three puncta occurs below the median line.

CYMBELLA CISTULA var. **MANSCHURICA** var. nov. Plate 5, fig. 4.

Valve cymbiform, with gibbous ventral margin and truncate apices. No row of puncta on the ventral side of the central nodule. Length, 0.0697 millimeter; breadth, 0.017. Striæ, 8 in 0.01 millimeter.

CYMBELLA CISTULA var. **HINGANENSIS** var. nov. Plate 5, fig. 5.

Length, 0.158 millimeter; breadth, 0.0255. Striæ, 5 to 6 in 0.01 millimeter. A distinct row of four puncta occurs below the median line.

CYMBELLA VENTRICOSA Kützing. Plate 3, figs. 16 to 18.

Valve lunate, with gibbous ventral margin and subacute ends. Length, 0.0238 to 0.024 millimeter; breadth, 0.0085. Axial area narrow. Striæ, 8 to 10 in 0.01 millimeter.

AMPHORA OVALIS Kützing var. **LIBYCA** Ehrenberg. Plate 3, fig. 19.

Valve lunate. Length, 0.0493 millimeter; breadth, 0.0221. Central area frequently uniting with an irregular black band across the striæ. Striæ on the dorsal side, 10 to 11 in 0.01 millimeter.

EPITHEMIA SOREX Kützing. Plate 5, fig. 6.

Valve curvate short, strongly arcuate. Ends capitate. Length, 0.0357 millimeter; breadth, 0.0102. Striæ, 6 in 0.01 millimeter.

EPITHEMIA ARGUS Ehrenberg var. **AMPHICEPHALA** Grunow. Plate 5, figs. 7, 8.

Valve arcuate, with capitate ends. Length, 0.0646 millimeter; breadth, 0.0102. Striæ, 3 in 0.01 millimeter.

EPITHEMIA ARGUS var. **LONGICORNIS** Grunow. Plate 5, fig. 9.

Valve long, linear, with round ends. Length, 0.1275 millimeter; breadth, 0.0136. Striæ, 3 in 0.01 millimeter.

EPITHEMIA TURGIDA (Ehrenberg) Kützing. Plate 5, figs. 10, 11.

Valve arcuate, with ends subcapitate. The raphe curved toward the ventral edge which it closely follows. Length, 0.0816 to 0.1445 millimeter; breadth, 0.00136 to 0.0017. Striæ, 3 to 4 in 0.01 millimeter.

EPITHEMIA TURGIDA (Ehrenberg) Kützing var. **VERTAGUS** Kützing forma. Plate 5, fig. 12.

Valve linear, lanceolate, with subrostrate ends. Length, 0.170 to 0.212 millimeter; breadth, 0.0153 to 0.0187. Striæ, 5 in 0.01 millimeter.

EPITHEMIA TURGIDA var. **WESTERMANNI** Kützing. Plate 5, fig. 13.

Valve short. Length, 0.0595 millimeter; breadth, 0.0102. Striæ, 3 in 0.01 millimeter.

EPITHEMIA ZEBRA Ehrenberg. Plate 5, figs. 14 to 16.

Valve elongate with rounded ends. Length, 0.0374 to 0.068 millimeter; breadth, 0.0102 to 0.0119. Striæ, 3 to 4 in 0.01 millimeter.

RHOPALODIA GIBBA (Ehrenberg) O. Müller. Plate 5, fig. 18.

Valve linear, arcuate on the dorsal, straight on the ventral side, reflexed at the extremities. Length, 0.1241 to 0.136 millimeter; breadth, 0.0102 to 0.011. From the side view, 0.0238 to 0.024 millimeter. Striæ, about 7 in 0.01 millimeter.

RHOPALODIA GIBBA var. **MAJOR** var. nov. Plate 5, fig. 19.

Valve very long. Length, 0.200 to 0.260 millimeter; breadth, 0.0102 to 0.012. Striæ, about 7 in 0.01 millimeter. Zone view, 0.022 to 0.023 millimeter.

RHOPALODIA VENTRICOSA (Grunow) O. Müller. Plate 5, fig. 17.

Valve gibbous in the middle on the dorsal side, straight on the ventral side, with reflexed apices. Length, 0.0425 to 0.0765 millimeter; breadth, 0.0112. Striæ, 7 in 0.01 millimeter.

HANTZSCHIA AMPHIOXYS (Ehrenberg) Grunow var. **XEROPHILA** Grunow. Plate 5, fig. 20.

Valve slightly arcuate, with rostrate apices. Length, 0.0374 millimeter; breadth, 0.0068. Keel puncta, 7 in 0.01 millimeter. Striæ, transverse, 18 in 0.01 millimeter.

HANTZSCHIA AMPHIOXYS (Kützing) Grunow var. **HINGANENSIS** var. nov. Plate 5, fig. 21.

Valve slightly arcuate, with rostrate apices. Length, 0.133 to 0.181 millimeter; breadth, 0.0136 to 0.0153. Keel puncta, 4 in 0.01 millimeter. Striæ, 15 in 0.01 millimeter.

CYMATOPLEURA SOLEA Brebisson. Plate 5, fig. 22.

Valve oblong, with subtruncate ends, constricted in the middle. Length, 0.1369 millimeter; breadth, 0.0296. Costæ about ? Striæ ?

CYMATOPLEURA SOLEA var. **GRACILIS** Grunow. Plate 5, fig. 23.

Valve long, with cuneate ends, constricted in the middle. Length, 0.192 millimeter; breadth, 0.026.

CYMATOPLEURA ELLIPTICA Brebisson var. **GENUINA** Grunow. Plate 5, fig. 24.

Valve elliptical, with cuneate apices. Length, 0.1406 to 0.185 millimeter; breadth, 0.066 to 0.074.

SURIRELLA ROBUSTA Ehrenberg var. **MANSCHURICA** var. nov. Plate 5, fig. 25.

Valve linear-ovate. Length, 0.1037 to 0.187 millimeter. Costæ, 2 in 0.01 millimeter. Frustule in zone view clavate.

SURIRELLA LINEARIS W. Smith. Plate 5, fig. 26.

Valve linear, lanceolate. Length, 0.125 millimeter; breadth, 0.0255.

ILLUSTRATIONS

PLATE 1

- FIG. 1. *Melosira varians* Agarth.
 2. *Melosira distans* Kützing.
 FIGS. 3 and 4. *Melosira italica* Kützing.
 FIG. 5. *Melosira italica* var. *genuina* f. *tenuis* (Kützing) O. Müller.
 6. *Tabellaria flocculosa* Kützing.
 7. *Tabellaria fenestrata* (Lyngb.) Kützing.
 8. *Meridion constrictum* Ralfs.
 9. *Meridion circulare* Agarth.
 FIGS. 10 to 15. *Fragilaria hinganensis* sp. nov.
 16 and 17. *Fragilaria hinganensis* var. *longissima* var. nov.
 FIG. 18. *Synedra ulna* Ehrenberg.
 FIGS. 19 and 20. *Synedra ulna* Ehrenberg var. *danica* Kützing.
 21 and 22. *Synedra ulna* Ehrenberg var. *amphirrhynchus* Ehrenberg.
 FIG. 23. *Synedra ulna* Ehrenberg var. *oxyrhynchus* Kützing.
 FIGS. 24 and 25. *Synedra acus* Kützing var. *delicatissima* W. Smith.
 FIG. 26. *Synedra acus* Kützing var. *angustissima* Grunow.

PLATE 2

- FIG. 1. *Eunotia pectinalis* Kützing var. *ventricosa* Grunow.
 2. *Eunotia pectinalis* Kützing var. *impressa* O. Müller.
 3. *Eunotia pectinalis* var. *impressa* forma *curta* V. Heurck.
 FIGS. 4 and 5. *Eunotia lunaris* Ehrenberg.
 FIG. 6. *Diploneis puella* (Schum.) Cleve.
 7. *Neidium iridis* Ehrenberg.
 8. *Neidium iridis* Ehrenberg var. *ampliata* Ehrenberg.
 9. *Neidium iridis* Ehrenberg var. *firma* V. Heurck.
 10. *Neidium affine* Ehrenberg var. *genuina* Cleve forma *media* Cleve.
 11. *Neidium affine* Ehrenberg var. *amphirhynchus* Ehrenberg forma *manschurica* forma nova.
 12. *Frustulia vulgaris* Thw. var. *asiatica* var. nov.
 13. *Navicula bacilliformis* Grunow.
 14. *Navicula radiosa* Kützing var. *manschurica* var. nov.
 15. *Navicula peregrina* Ehrenberg.
 16. *Navicula reinhardii* Grunow.
 17. *Navicula cincta* Ehrenberg var. *leptocephala* Ehrenberg.
 18. *Navicula* sp.
 19. *Navicula amphibola* Cleve var. *manschurica* var. nov.
 20. *Pinnularia mesolepta* Ehrenberg var. *stauroneiformis* Grunow.
 21. *Pinnularia brebissoni* Kützing var. *diminuta* V. Heurck.
 22. *Pinnularia nodosa* Ehrenberg.
 23. *Pinnularia legumen* Ehrenberg.

FIG. 24. *Pleurostauron acuta* W. Smith.

25. *Stauroneis phoenicenteron* Ehrenberg var. *genuina* Cleve forma.

26. *Stauroneis phoenicenteron* Ehrenberg var. *genuina* Cleve.

27. *Stauroneis phoenicenteron* Ehrenberg var. *amphilepta* Ehrenberg.

28. *Stauroneis phoenicenteron* Ehrenberg var. *vulgaris* Dippel forma *intermedia* Dippel.

29. *Gomphonema acuminatum* Ehrenberg var. *coronata* Ehrenberg.

FIGS. 30 and 31. *Gomphonema acuminatum* Ehrenberg var. *brebissonii* Kützing.

FIG. 32. *Gomphonema acuminatum* Ehrenberg var. *trigonocephala* Ehrenberg.

PLATE 3

FIGS. 1 and 2. *Pinnularia episcopalis* Cleve var. *manschurica* var. nov.

FIG. 3. *Pinnularia major* Kützing.

4. *Pinnularia major* Kützing forma *manschurica* forma nova.

5. *Pinnularia viridis* Nitzsch.

6. *Pinnularia viridis* Nitzsch var. *intermedia* Cleve.

7. *Pinnularia nobilis* Ehrenberg var. *intermedia* Dippel.

8. *Pinnularia nobilis* Ehrenberg var. *manschurica* var. nov.

9. *Gomphonema parvulum* Kützing var. *micropus* Kützing.

10. *Gomphonema constrictum* Ehrenberg var. *capitata* Ehrenberg.

11. *Gomphonema constrictum* Ehrenberg forma *curta* Grunow.

12. *Gomphonema sphaerophorum* Ehrenberg.

FIGS. 13 and 14. *Gomphonema geminatum* Lyngb.

FIG. 15. *Cymbella cuspidata* Kützing.

FIGS. 16 to 18. *Cymbella ventricosa* Kützing.

FIG. 19. *Amphora ovalis* Kützing var. *libyca* Ehrenberg.

20. *Cymbella cuspidata* Kützing.

PLATE 4

FIGS. 1 and 2. *Cymbella aspera* Ehrenberg.

FIG. 4. *Cymbella aspera* Ehrenberg var. *elongata* var. nov.

5. *Cymbella aspera* Ehrenberg var. *manschurica* var. nov.

PLATE 5

FIG. 1. *Cymbella heteropleura* Ehrenberg.

2. *Cymbella tumida* Brebisson var. *borealis* Grunow.

3. *Cymbella cistula* Hempr.

4. *Cymbella cistula* Hempr. var. *manschurica* var. nov.

5. *Cymbella cistula* Hempr. var. *hingansensis* var. nov.

6. *Epithemia sorex* Kützing.

FIGS. 7 and 8. *Epithemia argus* Ehrenberg var. *amphicephala* Grunow.

FIG. 9. *Epithemia argus* Ehrenberg var. *longicornis* Grunow.

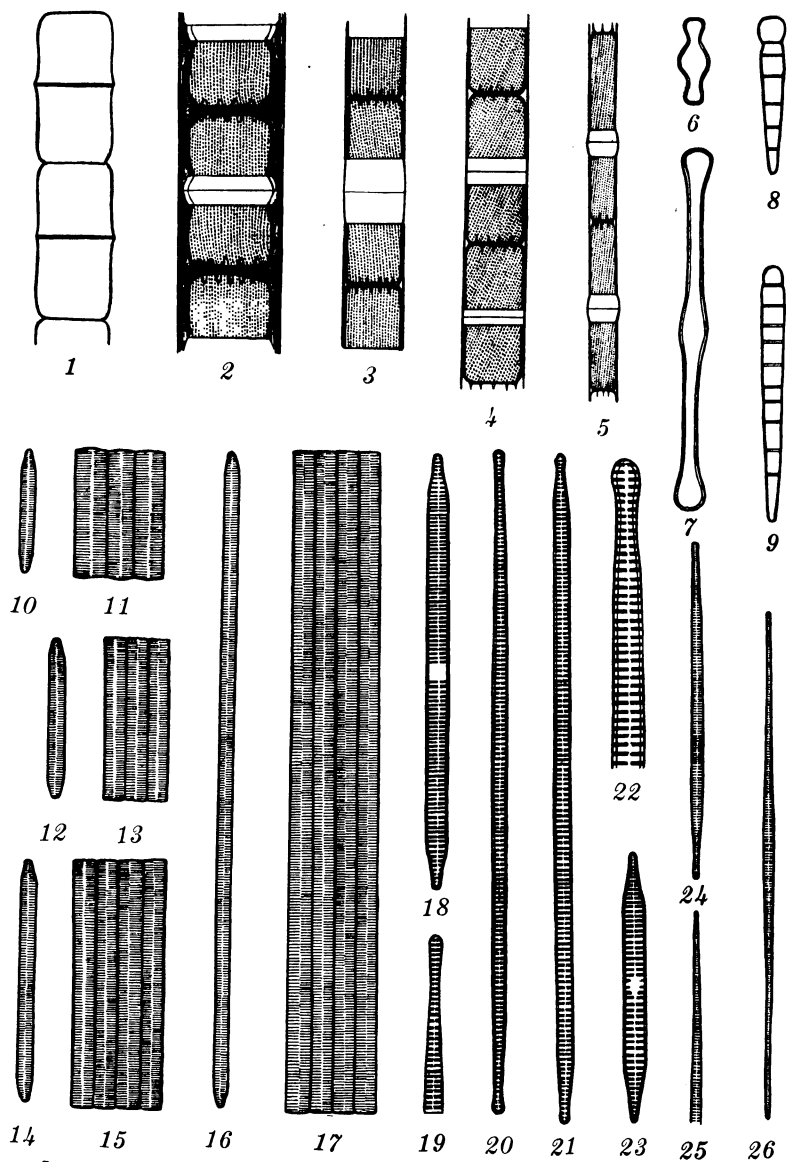
FIGS. 10 and 11. *Epithemia turgida* (Ehrenberg) Kützing.

FIG. 12. *Epithemia turgida* (Ehrenberg) Kützing var. *vertagus* Kützing forma.

13. *Epithemia turgida* (Ehrenberg) Kützing var. *westermanni* Kützing.

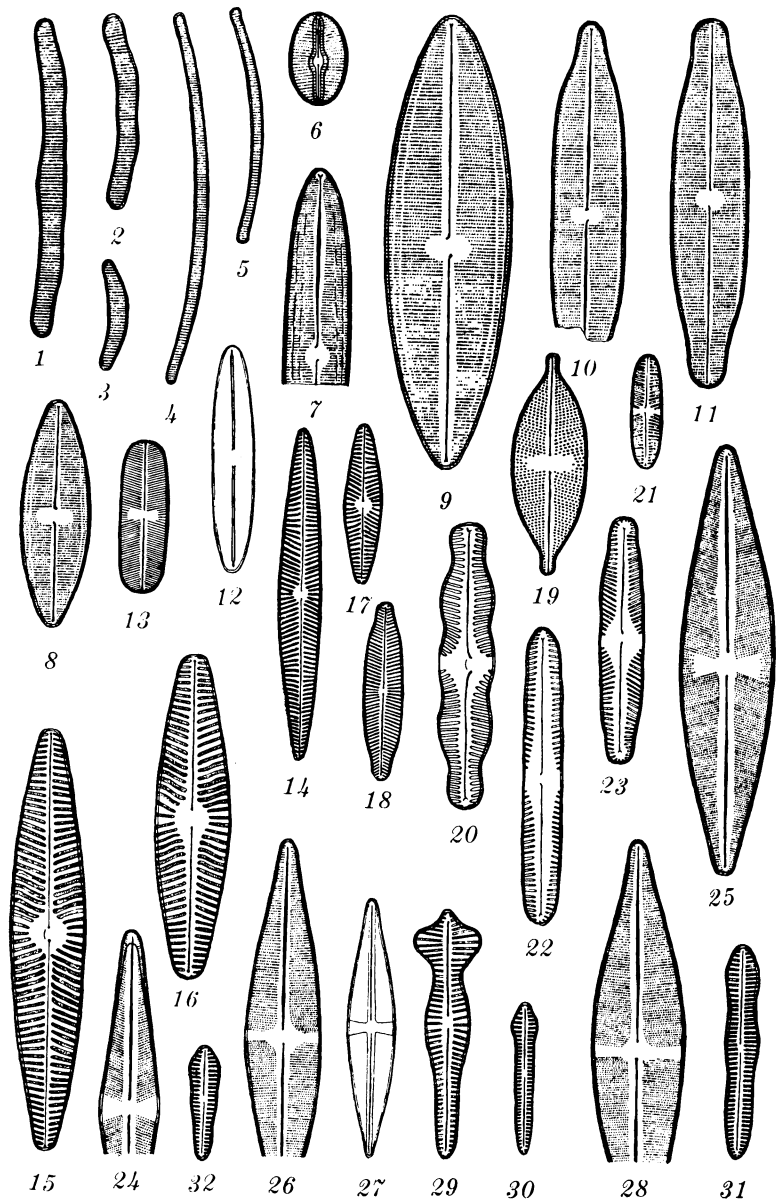
FIGS. 14 to 16. *Epithemia zebra* Ehrenberg.

- FIG. 17. *Rhopalodia ventricosa* (Grunow) O. Müller.
18. *Rhopalodia gibba* (Ehrenberg) O. Müller.
19. *Rhopalodia gibba* (Ehrenberg) O. Müller var. *major* var. nov.
20. *Hantzschia amphioxys* (Ehrenberg) Grunow var. *xerophila* Grunow.
21. *Hantzschia amphioxys* (Kützinger) Grunow var. *hinganensis* var. nov.
22. *Cymatopleura solea* Brebisson.
23. *Cymatopleura solea* Brebisson var. *gracilis* Grunow.
24. *Cymatopleura elliptica* Brebisson var. *genuina* Grunow.
25. *Surirella robusta* Ehrenberg var. *manschurica* var. nov.
26. *Surirella linearis* W. Smith.



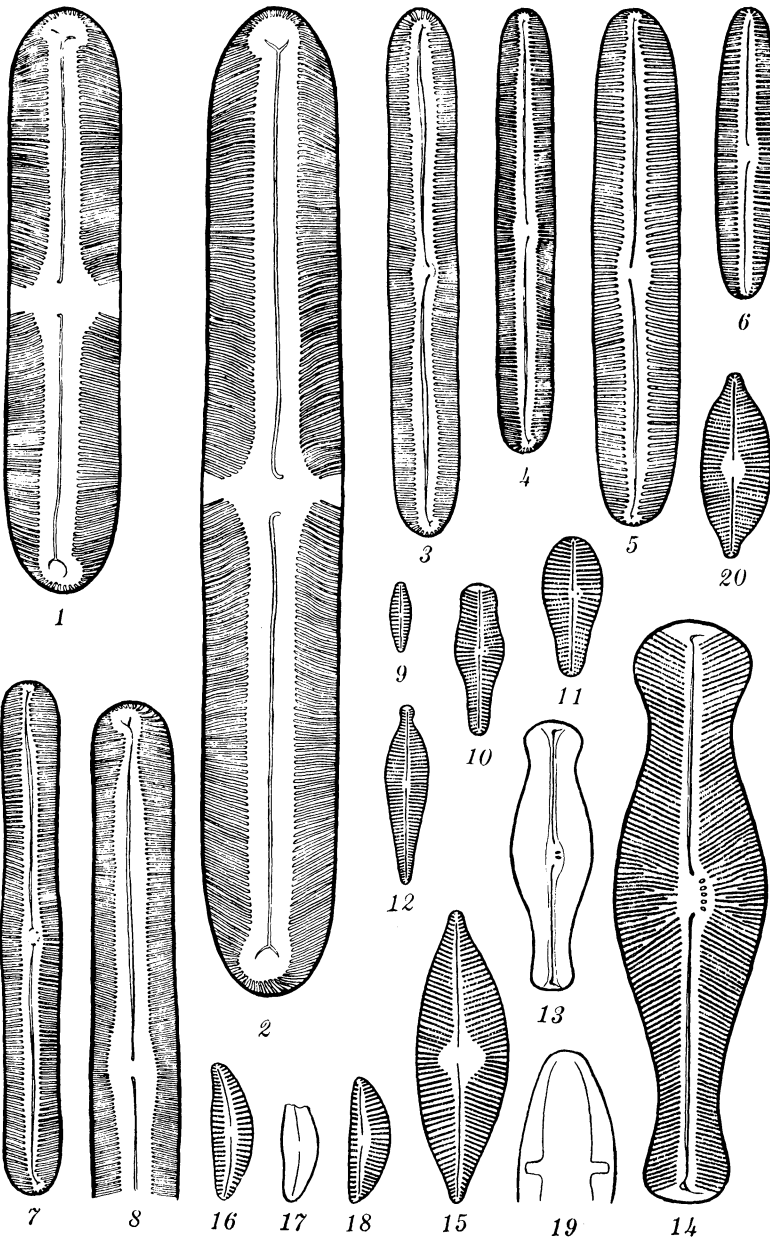
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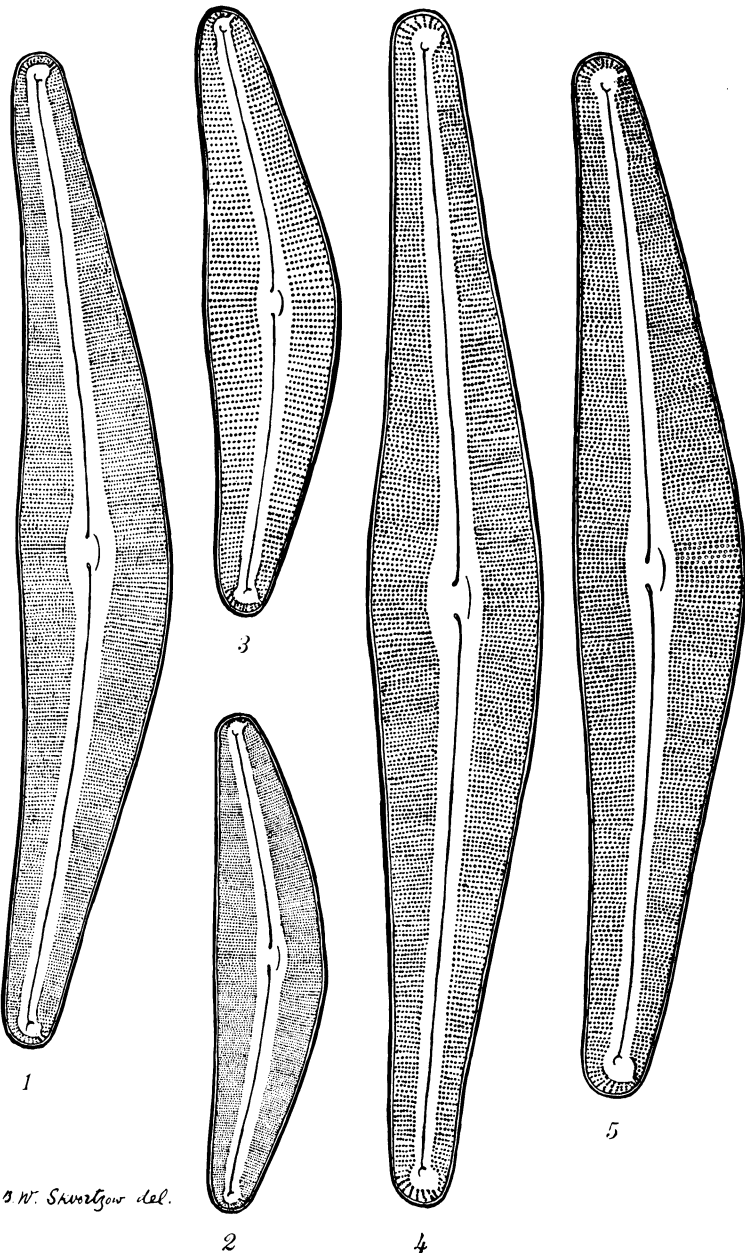


PLATE 4.

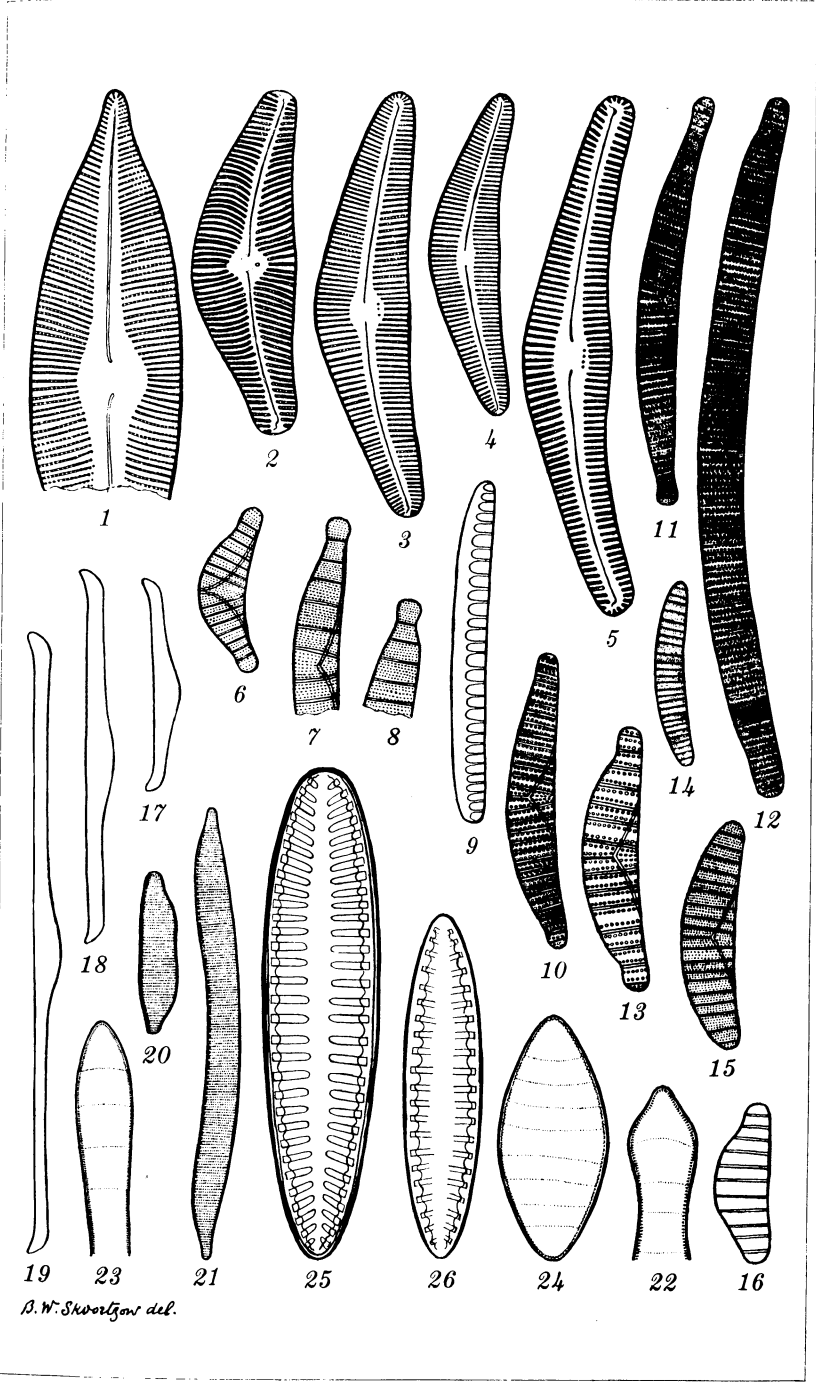


PLATE 5.

THE NATURAL HISTORY OF A PHILIPPINE NIPA HOUSE WITH DESCRIPTIONS OF NEW WASPS

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EIGHT PLATES

During a residence of more than two and a half years in the Philippine Islands, while engaged by the Experiment Station of the Hawaiian Sugar Planters' Association in entomological work, I was so deeply impressed by the abundance, diversity, and interest of the little creatures that shared my dwelling that I decided they should go on record. The observations that follow were made chiefly on the northern island Luzon, with supplementary notes from Mindoro, Panay, Cebu, Negros, and Mindanao. The College of Agriculture, at Los Baños, Luzon, was my home for the greater part of the time, and because of its situation, at the base of Mount Maquiling, extremely rich in plant and animal life, no better place for this study could have presented itself, for not only do the habitués of man's domicile flourish there, but many denizens of the forest make it their abode.

The building, to receive the full benefit of such occupancy, must be an open nipa house (Plate 1, fig. 1), preferably of some antiquity. No doubt the modernized screened-in structures with ceilings and tight wooden floors are more durable and in some ways excel in comfort, but they exclude such interesting household pets as the larger lizards, the banana frog, and the several bats, as well as the greater bulk of winged insects that are attracted to lights.

The nipa house is usually constructed of four kinds of material; namely, timber, bamboo, rattan, and nipa. For the foundation of the better type of house carefully selected limbs or tree trunks of the durable sort are employed. These *arigues*,¹

¹ *Haligue* or *haligi* (Tagalog) from which *harigue* or *arigue* (Spanish), usually the trunk of a tree from which the bark and branches have been removed, used as one of the supports of a house; a pillar or column of any material and shape.—EDITORS.

or main posts, support the house proper several feet off the ground, and if they are cracked, their splicing imperfect, or the wood liable to attacks of insects, to that extent is the natural history of the domicile enriched. Sawn lumber is much used for flooring. Bamboo, the giant among grasses, grows in huge clumps that rattle and creak weirdly in the breeze, and *Bambusa blumeana* Schultes is the most important element in house building. As poles it forms the grosser framework of the sides and of the roof (Plate 1, fig. 2) and, when split into slender laths, the more delicate structure there, as well as the flooring; and finally, it is woven as thin strips to make *sawale*, which in single or double sheets is used for wall material and to cover the sliding door and window frames. It is obvious that bamboo poles, particularly if cracked open or perforated, furnish excellent retreats for the more retiring creatures, whereas the double wall often harbors animals and nests of surprising bulk. Rattan, or *bejuco* (*Calamus*), is a slender climbing palm the younger parts of which are armed with annoying spines. Its stem is exceedingly strong and, when split into flexible strips, substitutes in great measure for nails, being used in securing the shingles to the bamboo framework and for other light work. The loose end of a bejuco cord hanging under the roof is often used as a nesting site by at least one species of wasp. The nipa palm (*Nipa fruticans* Wurmb) grows along tidal streams throughout the Philippines and is a very useful plant. It is rich in sugar, the sap furnishes an intoxicating drink, and the leaves are cut, folded, and fastened to form shingles, the roof covering for the majority of Filipino houses. Much animal life may lurk in such thatching. A bamboo net properly overlies the entire roof and protects it from the effects of heavy winds.

For our purpose it is necessary to consider the furniture, and even such embellishments as potted plants, in relation to the house fauna. Proximity to the forest, as exists on the slopes of Mount Maquiling, as well as to cultivated garden plants, helps diversify this fauna.

Included in this obviously very imperfect survey of the animal life of a nipa house, are the animals that make it their permanent home, the regular patrons, occasional visitors, and some of the creatures that work, recreate, or rest in the shelter of such a building.

Mention must be made of some of the important accessories of the more-typical country-side dwellings; of the useful though

ill-smelling carabao, or water buffalo, indispensable in the culture of rice, the staple food in the Islands; of the hard-working Philippine pony; of the specimens of the porcine world with their saddle backs; of the dogs and the cats; and of the domestic fowls that may roam where they will. The Philippine gamecock is an asset or a liability, as the case may be, to the roof that shelters it.

An interesting account of insects found in and about houses in India is given by Stebbing.²

Much has been omitted from the fauna of the Philippine nipa house, and it will become evident that I have favored some groups over others, placing undue emphasis, perhaps, on certain forms of life that seldom occur in houses but belong more properly to the forest. Enough has been written, however, to give the reader a general idea of what animal life may be found in houses of the type described.

Thanks are here extended to all of those who have assisted me in this work, chiefly to officers of the United States National Museum, for identifying various insects; to Dr. Wm. M. Wheeler, for determining most of the ants; to Prof. T. D. A. Cockerell, for determining certain of the bees; to Mr. Nathan Banks, for determining Neuroptera and Corrodentia; to Prof. S. F. Light, for determining the termites; and to the late Prof. C. F. Baker, dean of the College of Agriculture, Los Baños, Philippines, for determinations, material, and for other assistance.

INVERTEBRATES

SCORPIONOIDEA

The scorpion, a much-modified relative of the spider, has no antennæ, and the head and thorax are inseparably fused; on the other hand, it lacks a waist, is armed with a pair of strong pincers, and the venom resides not at the base of the chelæ or fangs,³ but in a poison sac and sting that terminate the slender part of the abdomen, which can be elevated and brought forward

² *Insect Intruders in Indian Homes*. Thacker, Spink & Co., Calcutta. 1-154; many illustrations.

³ In pseudoscorpions, which also are Arachnida much resembling a very diminutive scorpion, lacking the tail, and familiar to many of us as occurring under bark, among old papers (book scorpions), and also clinging by means of their strong pincers or chelæ to insects, Chamberlain, *Ent. News*. 35 (1924) 205-209, fig., has shown that for some groups a well-developed poison apparatus, residing in two or in all the fingers of the pedipalpi and opening near their tip, is present.

over the well-segmented body. Scorpions are solitary and nocturnal and attain their greatest development in warm countries. They do not lay eggs, and the newly born young cling to the body of the mother and are thus carried about for some time. They are considered long-lived creatures; and Fabre, who studied a species in the south of France, concluded that it took them several years to reach maturity. They range in size from about 15 millimeters to more than ten times that length. The west African *Pandinus imperator* attains a length of 20 centimeters, and the Indian *Palamnaeus swammerdami* (Simon) scarcely less.

Very large scorpions also occur in the southern Philippines and on islands to the south, but the house inmates treated here are not such monsters; *Hormurus australasiae* Fabricius, *Ischnuridæ* (*ischnurus*, slender tail), is the only one I have found guilty of this domiciliary habit about Los Baños. Large specimens of this species are 45 millimeters, or about 1.75 inches, in length. The forceps are large and stout, and the tail, though slender, is comparatively short. One specimen was found on the floor by my bed, probably having been dislodged from the nipa roof far overhead; another secreted itself between sheets of some coarse botany paper; but probably a more natural habitat was the base of the leaves of certain palms almost touching the house. Here a female scorpion was seen with her family of fourteen young clinging to her legs and the sides of her body, not by their pincers but by means of their regular legs.

ARACHNIDA

SPIDERS

Only a few of the many species of house-loving spiders can be considered here. Some of the Indian kinds are of very large size, for Pocock⁴ speaks of the genus *Poecilotheria* (Theraphosidæ), members of which have a body length exceeding 5 centimeters, as dwelling in trees or in the thatch of houses. Undoubtedly, the most widely known of all tropical house spiders is *Heteropoda regia* Fabricius, Clubionidæ (Plate 8, fig. 5), a long-limbed, swift creature of flattish posture with a body about 2.5 centimeters in length, that has been artificially introduced from the Orient into all tropical countries. It is known by several names; for example, the Nancy spider, in British Guiana; it is also called the huntsman; and, because of its powers of

⁴Fauna Brit. Ind., Arachnida (1900) 188.

progressing sideways (laterigrade), and perhaps also by reason of its pose, the crab spider. To many a newcomer this active creature, stretched out to intimidating dimensions on the wall, seems an objectionable roommate, but it is harmless and very beneficial in habits. *Heteropoda* comes under the category of hunting spiders, for it spins no snare but catches its prey by rushing upon it. It inhabits a variety of places, patronizing the hollows of trees, living among banana plants, and in the Hawaiian Islands is an object commonly observed in houses, while out of doors it may pass the day squeezed among the leaf bases of the larger plants of the sugar cane. The gauntness and sluggishness of individuals in houses often indicate that they do not always fare well indoors. The female encases her eggs, to the number of several hundred, in a large, flat button-like cocoon which she carries about between her legs, holding it in position with her leglike feelers (pedipalps) and her fangs. Ehrhorn⁵ and Pemberton⁶ found that about thirty-five days were required for hatching, and during all this time Pemberton's spider took no food but broke her fast on a cockroach immediately upon giving birth to her children. The spider is useful in the house, because it feeds on cockroaches. It comes out of its retreat at night and is often found on the floor. At Los Baños I have seen it eating a young *Scolopendra* centipede, a moth, and a long-horned grasshopper. It also feeds upon house ants of the genus *Camponotus*. Insects that fly to light also attract it. Wherever it travels it liberates a silken guide thread from its spinnerets.

Another laterigrade spider of even greater swiftness than *Heteropoda* is a far less-common and smaller species belonging to the genus *Hersilia* (Hersiliidæ). It is characterized among other ways by the comparatively short third pair of legs and by the excessively long spinnerets—a pair of jointed appendages which extend close together far beyond the end of the body. It is more of an outdoor spider, living in protective coloration on tree trunks, and occasionally is to be found in a head-downward, spread-out, and flattened posture on a porch post, occupying the same spot for weeks at a time. At first no web, apart perhaps from its silken bed, is evident; but closer inspection shows that each of the longer legs rests on a strong thread, the threads collectively radiating from her as a center, the strands

⁵ Proc. Haw. Ent. Soc. 2 (1912) 196.

⁶ Proc. Haw. Ent. Soc. 3 (1917) 273.

keeping close to the curvature of the post and joining outwardly to form a somewhat oblong rosette (Plate 4). Presumably, any small creature stepping on one of these threads would notify the proprietor thereby and a meal for the spider might result. It is an exceedingly swift spider that literally shoots around to the other side of the tree or post when disturbed.

Among the Attidæ (Salticidæ) are several species that may frequent houses. This very extensive family contains the familiar, thickset, little jumping spiders, sharp-sighted and sun-loving, that creep up to their prey and pounce upon it with surprising accuracy. They are often brightly colored and sometimes of rather striking form, particularly those resembling ants, with which they may then associate. They form no web except a sort of tubiform retreat in which to lay eggs, cast their skins and, in temperate countries, to pass the winter.

I shall now touch briefly upon a few of the sedentary kinds of spiders, that spin webs in which to ensnare their prey. Some of these, because of their habit of living in or near buildings, easily lend themselves to transportation and thus have spread to many countries. Foremost in size and striking appearance, though far less domiciliary than some others, are members of the genus *Nephila* (Plate 7, fig. 2) (Argiopidæ) that have representatives throughout the Tropics. Here exists an immense disparity in size between the two sexes for, while a female may be 5 centimeters in length of body and 12 to 15 in spread of legs, the male is probably not the hundredth part of her bulk. They are prettily marked in silvery yellows, reds, and blacks, but what chiefly brings them to notice is the very large, strong, and sticky, as well as annoyingly situated orb web they spin. These webs, which may be several feet in diameter, are made of smooth inelastic silk and some very strong, sticky, yellow threads, and have been known successfully to entangle small birds.

Nephila maculata Fabricius is a common oriental species that occasionally spins her orb on or near porches at the College of Agriculture, Los Baños. The comparatively small reddish male often rests near the outer edge of the great web which is not quite vertical, and in the center of the underhanging side of which the big female stays. Other smaller spiders, polished reddish ones to the number of a dozen or more, some with the abdomen markedly humped, may share her web, spinning in it delicate threads of their own to suit their needs, and feeding

upon insects entangled in the communal net. *Nephila* usually lives along wooded paths or about trees and bushes where a large variety of insect prey is available; those making their orbs about house porches perhaps do not thrive so well. The prey is often enshrouded in silk and then sucked of its juices, and the remnants, like any foreign material, cut out of the web and dropped. The large *Ornithoptera* butterflies sometimes fall victims to these spiders, and I once saw the big malodorous pentatomid bug *Tessieratoma longicornis* being eaten by one of these spiders that had spun on the porch. This victim was not yet dead and its odor was noticeable from a distance of a foot or more away; soon the arachnid, as though the flavor were too much for her, ceased biting into her prey, wrapped it up a little, bit off all of its sustaining threads but one, made this one more secure, and then commenced cleaning the terminal joints of her legs that had probably been affected by the bug's odor. Nevertheless, she later continued her meal upon this pungent morsel and was not done with it until the following day. At first, hovering toward dusk in a little swarm about the carcass, but eventually feeding in company with the spider, were a number of little fly midges, their heads in at the unoccupied wounds made by her. These spiders envelop their eggs in a silken cocoon. The habits of the giant wood spider (*Nephila maculata*) are treated at length by Hingston in India.⁷

The tetragnathous spiders (Argiopidae) are most easily recognized by their long projecting chelicerae, or mandibles, and elongate bodies and legs which, when at rest, are stretched out fore and aft. Two or three species were observed with their orbs fastened to the tips (leaflets) of the nipa shingles that projected over the eaves. The spiders remain concealed during the day, inconspicuously stretched out along the underside of the extremity of a palm shingle, but toward dusk much life is evident in this leaf fringe thrown out against the fading sky; nets are made over or repaired, the body being twisted awkwardly during this operation; then the artisans, assuming a more relaxed posture in the orbs, await their prey. These orbs are slightly off vertical and one measured 30 centimeters wide by 8 centimeters high; size and configuration are probably governed to a great extent by the points of attachment available. Little flies, caddis flies, and winged termites constitute a good

⁷ Journ. Bombay Nat. Hist. Soc. 28 (1923) 642 et seq., 4 parts.

part of their food. The tetragnathous spiders are very active orb weavers and many of them show a predilection for spinning over or near water. Some species have a very wide distribution and in the Hawaiian sugar-cane fields one or more kinds were often conspicuous during the bad leaf-hopper years and fed mainly upon this pest.

The family Pholicidæ is made up of very long-legged spiders represented in Philippine houses by at least two species. One of these hangs in its webs in some corner, and when disturbed shakes rapidly up and down with the structure. In aspect and coloration they strongly resemble certain "daddy longlegs" (tipulid flies) in the Philippines, which hang by their anterior legs to a horizontal spider thread and swing in unison.

Usually extending from beam to beam on the underside of the bamboo lath flooring are numerous, unsightly spider webs that catch the floor sweepings of dust, termite wings, etc., the snares of what appears to be *Artema atlanta*, the dominant spider under the floor. They crouch upside down in these thin webs that are domed in the center or to one side. An interesting account of common Indian spiders is given by Gravely.⁸

CHILOPODA and DIPLOPODA

CENTIPEDES AND MILLIPEDES

No matter how well ordered the nipa house, it is sure to harbor some of these elongate arthropods. Centipedes (Chilopoda) are usually provided with a single pair of legs to each segment, the first pair, however, being modified as poison claws with which the animals defend themselves or seize and subdue their prey. They are as a rule very swift of movement, particularly the forms that are not overburdened with an extreme length of body or multiplicity of ambulatory appendages. Millipedes (Diplopoda) have most of the segments equipped with two pairs of legs, and are generally inoffensive to man. Their movements are usually much slower than those of the centipedes, and they seek protection when attacked, mainly by curling up into a spiral and by exuding a strong fluid that is often capable of burning the skin. Centipedes are mainly predaceous. Millipedes, on the other hand, commonly eat plant food or act as scavengers in organic material.

⁸ Journ. Bombay Nat. Hist. Soc. 28 (1923) 1045-1050, 5 pls.

About Los Baños perhaps the most frequently observed centipede in houses is a very slender, many-legged one abundant in the leaf thatching and also to be found crawling along the floor or other woodwork. Its means of defense—as when roughly handled, or wounded—consists in exuding a luminous substance of distinctive odor from the sides of its body and thereby producing a greenish yellow light in the darkness. However, this centipede, small and slender, is harmless to man, but probably large species, of the well-known genus *Scolopendra*, that often frequent houses in the Tropics, are capable of causing great pain. Nevertheless, they must be regarded as generally beneficial, since they wander about at night in search of cockroaches, beetles, and other vermin. Occasionally, a more-venturesome one will attack very large quarry, as can be seen from the following quotation: °

I was disturbed one night by the noise of a sparrow in distress, and thinking that a snake had probably got hold of it, I pulled down the nest which was in the roof of my verandah, and found a large centipede clinging round the sparrow's body with its head buried in the bird's side. The centipede would not or could not let go its hold, and was cut away with a pair of scissors.

The sparrow had a hole in its side about half an inch in width and the same in depth, and was quite dead and fell to the ground when I pulled the nest down.

Millipedes are more rarely encountered in nipa houses. At Los Baños an ordinary-looking, cylindrical species occasionally crawls up into a stilted house and one such arthropod or, rather, half of one was seen to fall from the ceiling; the inference is that a house lizard had cut it in two.

ORTHOPTERA

BLATTIDÆ

COCKROACHES

Several species of cockroaches inhabit houses, and some of these are of cosmopolitan distribution. No list of Philippine species was made, but one is sure to find the large brown *Periplaneta americana* (Linnæus), and *Blatella germanica* (Linnæus), the Croton bug, among those present in nipa houses. *Periplaneta australasie* (Fabricius), much like an undersized

° Cumming, W. D., Journ. Bombay Nat. Hist. Soc. 15 (1903-1904) 364, 365. Ormara, Persian Gulf, July, 1903.

P. americana, is common at Los Baños and, if something appetizing was placed in the waste-paper basket in my room and at night a flash of light directed on this paper-lined receptacle, it startled the cockroaches, great and small, and they dispersed noisily. What appears to be *Lupparia adimonialis* Walker and a species of a genus rather close to *Lupparia* have also been taken indoors at Los Baños.

Most roaches of more or less domiciliary habit are nocturnal and fond of hiding during the day in dark places; there is one species (*Holocompsa debilis* Walker) that is often seen in the daytime in and on houses, but scarcely addicted, I believe, to frequenting the kitchen. This little species is between 4 and 5 millimeters long and moves about in sprightly, jerking fashion, and strongly suggests a small, thickset bug. It appears native to the East Indies.

ISOPTERA

TERMITES, OR WHITE ANTS

No list of tropical house fauna would be complete that did not include termites, those insidious social insects that fly to our lights in rustling swarms and pursue their hidden work of destruction within our house timbers and furniture. The study of these most interesting pests is fraught with difficulty, as an unsatisfactory classification shows, while their biology is of a secretive and often very complex nature and presents many problems to the student. Their colonies are frequently composed of immense numbers of individuals and this fact, coupled with subterranean or internal habitats, renders them foes especially difficult to cope with.

Despite their destructive habits, termites play a useful part in nature; to quote Imms¹⁰—

The role of subterranean termites has been compared by Drummond ("Tropical Africa") with that of earthworms. By means of their underground activities they keep the soil in constant circulation, rendering it permeable to air and moisture. Also the faecal matter of these insects serves to enrich the soil that is free from the burrows of these insects, and the number of individuals of the latter present defies all calculation.

Termites assist in the disintegration of dead timber. In some tropical countries the material from termite mounds is gathered and pounded down to make a very serviceable ground flooring for outhouses, tennis courts, etc.

¹⁰ A General Textbook of Entomology (1924) 266.

The Philippines has a wealth of Termitidæ, or *anay*, as they are called in the Tagalog dialect, and, while but thirty-nine species appear to have been listed and described from there,¹¹ many new ones will undoubtedly be found in the Islands.¹² Considerable work has been done on the life history and classification of termites, and a very good general idea of these insects is given by Wheeler¹³ and by T. E. Snyder.¹⁴ As many as eight castes exist among the Termitidæ and, as these are represented by both sexes, there can be sixteen different kinds of individuals.¹⁵ There may be three forms of functional males and females, the first of which is familiar to us as the flying specimens, and it is the female or queen of this form, when successful in starting a colony with her mate, that may develop an abdomen so large as somewhat to suggest a potato and renders her quite helpless to feed herself or to take a stroll. In fact, because of her increasing size, she is a prisoner within the royal chamber. Such a queen lives for years and lays an enormous number of eggs and is capable of producing all the castes peculiar to the species. The other two castes of functional females are flightless and usually of smaller size and less chitinized, and are not able to produce forms above their rank. The soldiers and the workers are sterile, but modified otherwise, as their names imply; the workers usually form the great bulk of the nest population. The soldiers have the head remarkably developed as to size, shape, chitinization, and function; many have powerful nipping jaws, others the power to eject a milky or a clear, repellent liquid through the front of the head, which is sometimes greatly produced as a snout. These soldiers, male and female, are true protectors, and frequently act as scouts and guard the line of march. As a rule, only the functional males and females have compound eyes.

Many kinds of termites make nests wholly or in part above ground, as mounds or carton nests; these are composed to a large extent of excreta and masticated soil and wood materials. There are, as in certain ants (*Atta*, etc.), termites that cul-

¹¹ Light, S. F., Notes on Philippine termites, Philip. Journ. Sci. 18 (1921) 234-257; 19 (1921) 23-64, 6 pls. and 3 text figs.

¹² About 1,500 species of termites have been described for the world, Cleveland, Quart. Rev. Biol. 1 (January, 1926).

¹³ Social Life Among the Insects. New York, Harcourt, Brace and Co. (1923) 1-375, illus.

¹⁴ Biology of the termite castes, Quart. Rev. Biol. 1 (October, 1926).

¹⁵ Wheeler, op. cit.

tivate fungus in subterranean gardens, as illustrated in a common large Philippine mound builder, *Macrotermes gilvus* Hagen;¹⁶ others are not thus agriculturally inclined, although a few collect grass, lichens, etc.; most of them, however, with the aid of an intestinal fauna of Protozoa, eat raw or decaying wood. Cleveland¹⁷ has found that in three of the four families of termites, namely, Mastotermitidæ, Kalotermitidæ, and Rhinotermitidæ, there is a large quantity of intestinal Protozoa; he says, "the protozoa in these insects weigh almost as much as the insects themselves." He goes on to say that most species of the fourth family, the Termitidæ, that had been examined had no Protozoa and that some of these lacking Protozoa have been shown to cultivate fungi which they eat "along with soil, cellulose and hemicellulose which the fungus has acted upon." Here each outgoing queen carries away a bit of fungus for a new colony.

Certain species, as, for instance, the Hawaiian *Coptotermes intrudens*, damage buildings, etc., both above and below ground, but these must nest in the soil (soil-nesting termites), while *Cryptotermes piceatus* of the same locality has been termed the dry-wood-inhabiting termite, from its custom of living in and damaging wood above ground.¹⁸ When in quantity some termites, if under dry leaves, etc., are capable of producing a sound comparable to grains of sand falling upon paper; this is done, I believe, by striking the head briskly against the débris.

Termites have many enemies, among them various anteaters (mammals); such birds as swallows and swifts, which secure them in quantity in their late afternoon flights; and lizards and numerous insects. Of the latter ants are probably the most formidable; larger carnivorous species, particularly of the subfamily Ponerinæ, carry the termites off bodily where they are exposed to their attacks; the smaller ants invade their burrows and drive them back. On the whole, however, the termites are so well organized and so prolific that they usually more than hold their own. There appear to be no insect parasites that destroy them wholesale, and the illustration (Plate 5, fig. 1)

¹⁶ See L. B. Uichanco, Philip. Journ. Sci. 15 (1919) 59-66, 4 pls., for descriptions and illustrations of *Macrotermes* fungus gardens in the Philippines.

¹⁷ Quart. Rev. Biol. 1 (January, 1926) 53.

¹⁸ See Muir and Swezey and Fullaway, Haw. Planters' Rec. 30 (July, 1926); and Fullaway, in Haw. For. & Agr. (July-September, 1926).

of a worker of what is probably *Microcerotermes los-bañosensis* Oshima with an exoparasite, or guest larva, clinging to its throat shows something not often seen; the affected termite, taken from a carton nest, did not appear handicapped by its burden which, presently dropping off, revealed a beetle (?) larva with a small head and three pairs of short legs, its general appearance recalling that of a rather smooth, glassy white lady-beetle larva. Termites have a diversity of guests inside their nests and also suffer from worm parasites within their bodies.

CRYPTOTERMES CYNOCEPHALUS Light.

Of this species Light¹⁹ says: "House termites, living in the dry, seasoned wood of planks and boards of houses, in furniture, in picture frames, etc."

CRYPTOTERMES (PLANOCRYPTOTERMES) NOCENS Light.

This has much the same habits as the preceeding. It is common at Los Baños, in wooden houses, and Light (1921, p. 47) believes it is the commonest house termite in Manila.

COPTOTERMES VASTATOR Light, MS.

This is held by Light to be the most injurious Philippine termite. At Los Baños it makes firm, rather narrow runways on houses, etc., from the ground.

MACROTERMES GILVUS Hagen.

The winged form of this large termite expands nearly 5 centimeters. The species is a common mound builder but also attacks house wood on the ground and "makes earthen runways over trees and shrubs, eating their bark."

NASUTITERMES LUZONICUS (Oshima).

This species is injurious to various trees and to "wooden parts of houses." It makes carton nests on tree trunks. The soldiers have long-beaked heads. A common species.

MICROCEROTERMES LOS-BAÑOSENIS Oshima.

Light (1921, p. 254) says: "One of our commonest Philippine termites. Makes hard nests at base of bamboo, cocos, *Pithecolobium*, etc., and builds tunnels over them. Occasionally attacks houses and furniture." A nest of this species, found on the lower slopes of Mount Maquiling, was over 30 centimeters in diameter, resting on the ground or somewhat embedded in it. It was made of stiff, strong, cartonlike material and was finely

¹⁹ Philip. Journ. Sci. 19 (1921) 40.

labyrinthal in character. No true queen was found, although at least a dozen complementary ones, of the second order, with fat bodies, chitinized sclerites, and wing pads, were present. This species is occasionally rather injurious in sugar-cane fields; as it hollows out the living stems of the plant sometimes for 30 centimeters or more above ground. The soldiers have long and effective mandibles.

THE "DAY FORAGER" *HOSPITALITERMES SARAIENSIS* OSHIMA

A ribbonlike stream of polished brown insects is moving steadily down one of the arigues; it continues its course along the ground and finally pours into a hole at the base of a hollow tree. This early morning scene is enacted by *Hospitalitermes saraiensis*, a "white ant," and perhaps the only Philippine species of the genus that probably owes its dark skin to a rather exposed manner of living, a habit that sets it quite apart from its more-injurious relatives. It is typically a woodland insect, whose orderly columns are often seen crossing some forest trail, and only where there is a considerable extent of shade and trees do we find it in the neighborhood of houses. Such a favorable habitation was the old forestry building perched well up on the slopes of Mount Maquiling. *Hospitalitermes* is frequently spoken of as diurnal; this is not altogether correct, for the truth of the matter is that the colony has so much outdoor work to do that the entire night and a good part of the day are required to accomplish it.

It is quite worth while to devote a little study to these remarkable termites; their life above ground is fairly easy to observe and is what must chiefly concern us. Their hours of toil in the open are naturally somewhat irregular, but a late afternoon or early evening will generally find their dark shining forms massed about the entrance of the burrow, preparatory to a forage in the field. As one views the multitude that seems so reluctant to leave its domicile, he will see that there are two forms of these termites present, each with its own line of duty; the soldiers with their elephantlike brows and noses, long-legged and more active, act as scouts and guards and see that the way is clear of danger, and the workers, more lowly and less venturesome, that form the bulk of the population of the nest. The soldiers do not have the powerful nippers that characterize this caste in the majority of species of termites, but their retort-shaped heads secrete a fluid which is discharged through the long "snout" and serves to keep off enemies. Nasute

soldiers in the termites are also credited with using this fluid as a cement for constructing the nest.²⁰

On the dull afternoon of July 24, 1921, preparations were being made for an excursion. At 4.50 p. m., eighteen snouted scouts appeared on the arigue; they seemed in an undecided frame of mind, advancing, spreading out, retreating; at one moment eight were to be seen, then there were but two, far up the post. Down below and some distance away a mixed crowd of termites was issuing from the ground. Shortly after 5 p. m. none of the insects was visible above; the few scouts were in touch with the guarded line, now apparently well under way; but at 5.50 p. m. it was drawing back, and we could not but mark its caution. Finally, at 6.30, when darkness was coming on, the column with some assurance had ascended the arigue to a considerable height, workers and scouts intermingled, and a few had spread out on the bamboo porch. So the line swelled, two or three workers abreast, well protected by the outfacing guards, and while there may have been some back-and-forth movement, it rapidly climbed upward. Denser and denser it became, the hurrying throng increased to ten or more workers wide, and in addition, a more-open sheet of them had formed on the arigue; but the objective was a large beam along the wall of the room, along which they spread from end to end. Here and there workers collected in groups, biting off tiny splinters and chewing them into a pulp. There were many thousands of these foragers here and no doubt as large a number in the nest. At a quarter to ten they were still pouring out of the ground, but there were also workers, carrying before them in their jaws pellets of comminuted wood, entering the ground. At 10.05 p. m. by far the greater bulk of travelers was still outbound. Here observations were suspended until 6.15 the following morning, when many were still on the beam in the room, but there was a general movement homeward (Plate 5, fig. 2). For a while two little groups of pellet carriers at the base of the post indicated congestion in the traffic, but at last, with a few soldiers properly bringing up the rear, all were safe at home.

The pellet carriers form only a small percentage of the army, because one pellet is the work of many individuals, as we shall now see. The numerous chewers of wood, which do not appear to be of a different caste from the pellet carriers (perhaps

²⁰ See Sharp, *Cambridge Natural History* 5 (1895) 370, 371.

the work of both is interchangeable), are intent upon their work, heads applied to the perfectly sound wood, whether it be the beam or the bamboo flooring. Tiny splinters appear and soon a masticated mouthful is collected. Sparse among the mass of termites, workers carrying large or small loads stand around or walk about a little. From time to time one of these is approached by a single wood chewer or by a little group of them; it faces these readily and accepts their contribution stuck on to its load as a little mass of moist, rather stringy, and perhaps regurgitated paste. Thus the burden increases in size, passers-by adding to it until it is deemed of sufficient bulk to be borne nestward. Presumably most of the wood chewers return to the burrow without any apparent load. This work may begin comparatively early in the evening and be maintained up to 8 o'clock or even later on the following morning.

The damage these *Hospitalitermes* do to woodwork seems very superficial for, while they may patronize the same area day after day, the layer removed is almost imperceptible. It is presumed that at least some of this cellulose is used as food, and some perhaps for making the termitarium. Away from human habitations the materials are probably collected from the trunks of trees, and one lot was observed making up pellets from the stem of a royal palm (*Oreodoxa regia*). Sometimes they are very late in returning home, for it may be after midday before all are within; they are, nevertheless, careful to keep their line of march as much as possible in the shade, and the path on which their multitudes pass becomes smooth and well defined. Both soldiers and workers sometimes vibrate the body back and forth. The soldiers are always alert and stand high on their legs, the forepart raised more than the posterior, giving them the appearance, when stopped, of trying to scent danger; they diffuse a rather pungent spicy odor, somewhat like cinnamon; crushed soldiers smell strongly of it, workers little, if at all.

The mouths of an occupied nest are often if not usually shining with the dark-colored inhabitants which frequently overflow it; both soldiers and workers are apparently blind. The large, dark, adult, winged forms, however, are provided with both simple and compound eyes, and come out of the nest at dusk, wander timidly among their apterous brethren, and seem very loath to take wing. One or two very short flights were observed early in December.

To test the aggressiveness of the defenders, an active, long-legged, pale red ant, *Anoplolepis longipes* Jerdon²¹ was placed in their midst and near the entrance to the burrow; it hurried away, but I repeated the performance until some of the workers grabbed the ant's legs in their mandibles, the soldiers only pointing or jerking their long noses at it, no doubt with an unpleasant effect. Blowing one's breath upon the termite stream makes it "freeze" or halt instantly in its tracks; then it breaks up in confusion, but in the end the march is resumed in good order. Stirring up the nest immediately brings forth the pungent spicy odor, and some soldiers and workers crawl over the devastating hands, the workers feebly attempting to bite.

One of the larger nests—if, indeed, the several proximate nests were not all joined together underground—was dug up in an unsuccessful attempt to find the queen. The nest was in the hollow of a *Cordia myxa* tree, extending against it partly above ground, and below, following an old root for 30 centimeters or more beneath the level of the soil. Above, there was a sort of embankment of packed earth particles. The body of the nest consisted of an aggregate of thin-walled chambers, dark sooty brown or black, forming a sort of labyrinth, and was crowded with termites. The strong spicelike odor permeated the structure. No eggs were found, though tender, white young, and soldiers beginning to brown up were plentiful. Some of the workers became aggressive, but most of the army ascended the *Cordia* trunk carrying in their jaws many of the young. A few of the latter walking by themselves were not long allowed to do so by their solicitous caretakers. A few of the young (nymphs) had wing pads. The heart of the nest, still farther underground, was not reached. This ruined structure, with its inmates scattered about in wild confusion, was not long in attracting large predaceous muscoid flies of the genus *Bengalia* (*B. latro* de Meijere), as well as other dipterans of smaller size, that flew about with a distinct high-pitched buzz and that did not appear to be of carnivorous habits.

Bengalia is nothing if not bold, nimble, and well able to take care of itself where swarms of ants or termites are concerned. These big brownish flies, which are sometimes over a centimeter in length, are provided with a stout beak terminating in a dilated muscular tonguelike organ strongly armed with

²¹ Identified by Wm. M. Wheeler.

longer and shorter bristles. The voracious dipter, posting itself at some fruitful spot near the passing fugitives, suddenly lunges forward and snatches up in its beak one of the young termites, white and tender, carries it nearby, where it is not likely to be disturbed, and in a very short time sucks out its juices. Its appetite seems insatiable; no sooner is one victim disposed of than another is sought; *Bengalia*, indeed, does not hesitate to snatch a young *Hospitalitermes* out of the jaws of its carrier; the latter not infrequently refuses to let go its burden immediately and so both are borne off, the carrier soon releasing its hold, however. Close at hand, among the dry leaves, a nest of an ant (*Anoplolepis longipes*) was disturbed and, much concerned, the workers grabbed their cocoons to transport them elsewhere. Here *Bengalia* was also on the watch; it would quickly seize a cocoon and, usually holding it in the forepaws, pass its length up and down along the end of its beak and suck it until well shriveled, then drop it and be on the lookout for another morsel. Twice there was a tug of war between fly and ant for the possession of a cocoon, the carrier refusing to part with the enshrouded babe, the fly, perhaps unconscious of the third party, thoroughly enjoying the tidbit.

When a flight of termites, or white ants, is on, and scores are attracted to light, *Bengalia* often appears in considerable numbers, making a fairly audible hum. None was seen attacking the termites, although this does happen, as recorded by E. E. Green, in Ceylon ²² and by others. In Africa, *Bengalia* robs *Dorylus*, the fierce driver ants, of their pupæ when on the march; other species of ants are also deprived of their young or of their food.²³ In a similar manner the related *Ochrimyia* ²⁴ of India robs various ants, such as *Lobopelta*, etc.

In the Maquiling forest the somber *Bengalia* is often seen sitting on a slight prominence and shifting beside a column of ants and robbing them of their food or their young. In the case of *Phidologiton*, for example, when carrying termites this is rather easily accomplished, but with the doryline ants

²² Trans. Ent. Soc. London (1908) XXVI and XXVII.

²³ Lamborn, W. A., and others, Trans. Ent. Soc. London (1913) CXXIII-CXXIX.

²⁴ *Ochrimyia* appears to be a synonym of *Bengalia*. In Africa the larva of *Bengalia* burrows under the skin of certain mammals, including man, and pupates in the ground (see Fox in *Insects and Diseases of Man*, Blakiston's Son and Co., Philadelphia).

(*Aenictus*) that carry their burdens beneath them and between their legs considerable difficulty may be encountered, as the burly fly is forced to make the attack from the side with many failures resulting.

While *Hospitalitermes* does considerable excavating to accommodate its nest, the work is not done with the precision or the rapidity of true ants; the particles brought up may be very small and apparently in part disgorged from the mouth, or they may be as bulky as the worker itself. In this way a low mound, a labyrinth of burrows, may be formed about the entrance. A small, moderately elongate, deep purplish brown spider with paler legs, in appearance not greatly unlike *Hospitalitermes*, utilizes the earthlike material in the mounds in building a short tube in the edge of the mound roofing and in which it lives; but the spider does not appear to associate itself entirely with the work of this species of termite. What seems to be *Hospitalitermes* also makes covered ways along the trunks of trees.

The habits of termites of the genus *Eutermes*, of which *Hospitalitermes* is sometimes considered a subgenus, have been studied by Bugnion in Ceylon.²⁵ His figures of *Eutermes monoceros* show that it is closely related to *Hospitalitermes saraiensis* and is referred to as the Ceylonese "black termite." This species has much the same habits as the Philippine *Hospitalitermes*, although the *Eutermes* was noted gathering lichens in its forages. In repairing a breach in their tunnels, the Ceylonese insects were found to use a bit of soil moistened with anal fluid (p. 183). In a photograph (Bugnion's Plate 7, fig. 1) the line of march of *Eutermes monoceros* plainly shows the marginal, outpointing soldiers.

There are other, more or less diurnal Termitidæ. A rather dark Philippine species, though lighter in color than our *Hospitalitermes*, travels like it in the Maquiling forest. On the trunk of a tree in the British Guianan "bush," I have seen blackish termites proceeding during the afternoon in the same style as does the Philippine "day forager;" that is, as a stream, several individuals in width, and flanked by long-nosed soldiers.

Some of the neotropical termites of the genus *Syntermes* are day foragers; Bequaert ²⁶ writes as follows on this habit:

Syntermes grandis (Rambur) and *Syntermes brasiliensis* Holmgren. Both these large species of termites were observed at Vista Alegre, on the

²⁵ Bull. Mus. D'Hist. Nat. 20 (1914).

²⁶ Ent. News 36 (1925) 294.

Rio Branco, September 6th. They were foraging in broad daylight and sunny weather, between 9 and 10 A. M. The soldiers and workers had spread over the soil, but not in very large numbers, and were busily engaged in collecting stalks and leaves of grasses and other low plants. The two species, of which *S. grandis* is much larger, were working but a short distance apart, although on quite distinct areas. In each case the termites carried their burdens into a number of large openings leading into deep vertical channels in the sandy soil. The nest itself could not be reached.

Hodotermes havilandi lives in South Africa. It is a grass-cutting termite whose soldiers and workers possess faceted eyes and forage during the heat of the day. Rather large bits of grass are cut off. Haviland, who made these observations,²⁷ says further that around each nest hole "is a patch over which the grass has been cut quite short." Thus are these termites somewhat comparable to those agricultural ants (Formicidæ), such as *Pogonomyrmex occidentalis* of the Great Plains of the United States, that clear away all vegetation for a considerable radius around their nest aperture.

TRICHOPTERA

CADDIS FLIES

Caddis flies (Plate 3, fig. 1) are four-winged, mothlike insects with very long antennæ and the wings clothed with hairs. The early stages are passed in the water over the surface of which the adults are often seen in swift erratic flight. They are commonly attracted to lights and, indeed, being very early-evening flyers, may appear in an open room before any lights are on. Only one or two species were noticed frequenting houses on Mount Maquiling; a gray-brown kind was rather conspicuous, flying near and under the eaves of nipa shingling, two or more sometimes sporting together. I believe they roost here during the day and form part of the food for the tetragnathous spiders, whose webs often adorn the tips of the marginal palm shingles. The species collected by me, about houses on Mount Maquiling, and identified by Nathan Banks, are *Dipseudopsis bakeri* Banks, *Oecetinella confluens* Ulmer, *Oecetinella apicipennis* Banks, and *Notanatolica gibolensis* McLach.

²⁷ Teste Sharp, Camb. Nat. Hist. 5 (1895) 384, 385.

NEUROPTERA

MYRMELEONIDÆ

ANT LIONS

MYRMELEON CELEBESENSIS McLachlan.²⁸ Plate 7, fig. 1.

The fine, dry, loose soil beneath the stilted Philippine houses is frequently pitted with little funnellike depressions, an inch or more in diameter, which harbor the squat, sickle-jawed larvæ of the ant lion. These patient creatures pass a great part of their existence at the bottom of the funnel with loose sliding sides, waiting for some insect, most frequently perhaps an ant, to tumble down into their jaws and be devoured. When full-fed the larva spins a roundish silk-and-soil cocoon, from which hatches, in due time, a delicate, long-winged, and long-bodied insect, somewhat resembling a dragon-fly, but of weaker flight and of nocturnal habit. While the large numbers of pitfalls indicate that *Myrmeleon celebesensis* is common, the adults are not very often seen, though occasionally attracted to light or found resting indoors.

Myrmeleon angustipennis Banks is also reported from Mount Maquiling and vicinity,²⁹ and probably likewise digs into and under the shelter of houses, etc.

CORRODENTIA

PSOCIDÆ

BOOK LICE

This large family of usually minute, winged or wingless insects has been much neglected by entomologists. A few hundred species have been described; probably several thousand exist. They are familiar to most of us as very small, soft-bodied insects, that occur about old books, in dusty places, etc.; most kinds, however, live out of doors, where they are found on trunks, branches, and leaves of trees, on palings, etc. They feed upon the paste of book bindings, dead organic materials, lichens, fungi, etc., and sometimes figure as museum pests in entomological

²⁸ Identified by Nathan Banks.

²⁹ Banks, N., Philip. Journ. Sci. § D 11 (1916).

collections. They develop much as do cockroaches and termites, their form changing but little in the successive moults. The psocids are often beautifully marked and strangely formed. The largest species appears to be a South American one, which has a wing expanse of about 2.5 centimeters. Many kinds live gregariously, upon the trunks of trees, on posts, etc., and such colonies are frequently covered by a thin, more or less protective web, that is spun from glands opening into the mouth. There are several kinds of Psocidæ that may be domiciliary in the Philippines; one species, found on a porch post, served as food for *Rhopalum domesticum*, a tiny black wasp. *Myopsocus enderleini* Banks³⁰ is a rather large, dull brown, winged form that lives in outhouses, etc., at Los Baños. *Atropos divinatoria* (Müller) is the common wingless psocid found indoors in many parts of the world. It is frequent in ill-kept entomological collections. Timberlake has found a tiny myrmarid wasp parasitic in its eggs.³¹ Twelve genera and fifteen species have been described by Banks from the Philippines.³²

LEPIDOPTERA

BUTTERFLIES THAT PATRONIZE THE NIPA HOUSE

Any rural dwelling, the garden of which boasts a few banana plants, palms, and bamboos, is likely to have certain butterfly visitors, chiefly dusk-flying species that pass their early life upon these plants and are drawn to man's abode by the occasional shelter and on account of the lanes of flight it affords. I believe that the houses perched upon the lower slopes of Mount Maquiling are particularly favored by insects of this type, because the greater variety of vegetation there means more food plants and more species.

Such incomplete data as I possess on these butterflies make their treatment here a matter of but a few lines.

NYMPHALIDÆ

MORPHINÆ

AMATHUSIA PHIDIPPUS Linnaeus. The "coconut nymphalid." Plate 2, fig. 1, pupa; Plate 3, fig. 3, adult.

At the approach of sunset, a somber brown butterfly, expanding about 10 centimeters and with the hind wings produced into

³⁰ Identified by Nathan Banks.

³¹ See Proc. Haw. Ent. Soc. 5 (1924) 447.

³² Philip. Journ. Sci. § D 11 (1916).

a short tail, may frequently be observed flitting about nipa houses in a graceful bounding flight, taking this constitutional with some degree of regularity, now circling as far as the back porch and now fetching up among the palms and bananas to the rear. Occasionally, *Amathusia* will enter through a doorway or a window, or it may suddenly abandon its course to pursue some intruder of its own kind. Such antics may be sustained until dusk is well advanced, though I do not think this butterfly is relatively active much after nightfall. Seldom was it seen flying about lights. Shortly before sunrise it flits about for a while, but passes the day on some shaded arboreal perch; not infrequently, however, one would be disturbed beneath the old forestry-station building, where it had been resting under the split-bamboo flooring, or on a beam, or arigue. More rarely is the butterfly found within a house during the day, although it occasionally rests there in the night; then *Amathusia*, head downward, with the wings over the back, may be very closely approached and even captured with the fingers.

Rather late on dull afternoons, one of these insects may be observed carefully laying her eggs on the underside of a banana leaf, on a coco-palm leaf, or on a royal-palm (*Oreodoxa regia*) leaf, the food plants of its larva; the latter like its parent shuns daylight, lying concealed on a bed of silk, spun at the base of a leaf, or other secure and nearby place, whence it sallies forth at nightfall following and augmenting its silken trail to the feeding grounds. Though finally of large size, the *Amathusia* caterpillar is a very quiet creature, not to be discerned at once, as it rests well appressed upon a green coco-palm leaflet. It attains a length of between 7.5 and 10 centimeters, the head is adorned with a pair of fine, spiked, tuberclelike processes, while at the end of the body are two simple processes. The body is green and greenish striped, the head brown and green, and the legs largely brownish. It is rather thinly clad with longer and shorter hair. When full-fed the caterpillar first wanders about for a while, but finally suspends itself by the tail from a palm-leaf petiole, or beneath a raised house floor, and sheds its skin to form a stout chrysalis (Plate 2, fig. 1) about 5 centimeters long and with a bifurcate headpiece; in due time the large brown butterfly, that will again flit in the gathering shadows, is disclosed. There seems to be a continuous round of broods of *Amathusia*.

HESPERIDÆ

"SKIPPERS"

ERIONOTA THRAX Linnæus. The "banana leafroller." Plate 3, figs. 4, 7, and 8.

This is a large brownish butterfly with several windowlike spots on the forewings and which expands to about 7.5 centimeters. Like others of the family it is noted for its swift flight. It is one of the several species of Philippine skippers that are chiefly twilight fliers. It has a rather wide oriental distribution and is sometimes numerous enough to damage the banana plants considerably. J. C. Kershaw,³³ in speaking of the adult says:

The largest Hesperid here, and a very common insect wherever there are banana plants, but it seldom flies much during the day and thus escapes notice. It becomes very active about dusk, flying at great speed about the tops of bananas and other foliage. Occasionally it rests from its wild gyrations on the tip of a leaf, when a mate will often suddenly appear and both will dart off; together. I have captured this insect at flowers as late as 9.00 P. M., and it probably flies much later if the night is propitious.

I have not found these butterflies to be frequent house visitors; occasionally they will rest or sport about beneath a highly raised house. The eggs are hemispherical and well ribbed from the apex and are not quite 2 millimeters in diameter. The little caterpillars cut obliquely inward from the edge of the banana leaf and form a tube by fastening this rolled strip with silk; a large larva makes a large roll as illustrated. Here it also pupates. A full-fed larva is fusiform-cylindrical with a large head set on a small neck, as is usual among the Hesperidæ, and is covered with a whitish flocculent substance. The pupa is often parasitized by chalcid wasps (see Plate 3, fig. 4).

There are several other large skipper butterflies that disport themselves about the house, flying into the rooms and alighting upon the walls or floors; one of these is the coconut skipper (*Padraona chrysogona* Plotz.), whose larva also feeds on the betel-nut palm (*Areca catechu* Linnæus),³⁴ while another is a very stout species whose larva of bizarre coloration eats the leaves of *Schefflera* and of *Polyscias nodosa* (Araliaceæ).

³³ Butterflies of Hongkong (1907) 127.

³⁴ See Woodworth, Philip. Agr. 10 (August, 1921).

DIPTERA

FLIES

Apart from the common oriental housefly (*Musca vicina* Macquart) and the far more unpleasant and dangerous green-bottle flies, are a number of Culicidæ, or mosquitoes, and certain others, chiefly parasitic on the prey of household wasps, or on the immature wasps themselves.

In unscreened houses many species of mosquitoes may gain entrance, among which are *Mansonia brevicellulus* Theobald, *Anopheles philippinensis* Ludlow, and *Aedes (Stegomyia) variegatus* Bigelow. *Megarhinus amboinensis* Dol. is a very large mosquito with the abdomen of an iridescent blue-purple luster and adorned at the tip with widening tufts of hair. Despite its large size, long beak, and shrill note, it seems never to attack man and is probably only a feeder on plant juices or secretions. The larva of *Megarhinus* is carnivorous and, as it devours the young of other mosquitoes, is thereby beneficial.

Pachyophthalmus signatus Mg. of the parasitic family Tachinidæ was reared from the cell of *Rhynchium atrum*, a eumenid wasp that very commonly nests in houses and stores moth caterpillars, and from which most probably the flies had issued.

Several species of bee flies (Bombyliidæ) are to be found in and about the more-open houses and are parasitic, in such cases, on the immature stages of Hymenoptera. *Anthrax fulvula* Wd. (?) is adorned largely with golden vestiture and has the wings somewhat darkened along the costa and toward the base. One was reared from the nest of the mud dauber *Sceliphron deformis*. *Anthrax* sp. has a blackish body and the wings except about the outer margin overrun with brownish. This species and *Exoprosopa* sp. are also Bombyliidæ that are to be found about houses.

SIPHONAPTERA

FLEAS

Not much interest was taken in preserving fleas, and *Pulex irritans* Linnæus is the only one represented in the collection of household insects.

HYMENOPTERA

BEES, WASPS, AND ANTS

HOUSEHOLD WASPS

The wasps associated with a nipa house in the Philippines are without doubt its most entertaining fauna. They number quite thirty species, not including those that live as parasites upon them. While some are but occasional visitors, others are members of every properly situated household. Since only one or two of the species are of social habit, thus living in communities and defending their nests, with that possible exception nothing is to be feared from wasps in man's abode.

Vespa deusta Lepeletier, a very large paper-making yellow-winged wasp, often inspects the more-open rural dwellings in her search for the nests of other wasps which she robs for her own needs. A smaller, though still formidable species, probably *Vespa luctuosa* Saussure, a useful if clumsy enemy of obnoxious flies, will occasionally commence her paper nest under the eaves of some nipa house where the environment is not too civilized; one such insect, a queen, of course, built several cells from the end of the stout pedicel and laid an egg in each; the work, however, progressed slowly and, while she guarded her nest by resting on the cells for long periods, she eventually deserted this embryonic household.

The genus *Icaria* contains over one hundred kinds of social wasps, on the average of rather small size; they are mainly tropical insects characteristic of the Old World. The carton or paper nests they construct vary much with the species; for example, *Icaria gregaria* Saussure of Australia has a nest consisting of an unprotected comb of more or less oblique cells, hung at one end, and often supported laterally as well, by a strong stem to a leaf, twig, barbed wire, etc.; the affair may vary considerably in shape, and I have seen a long slender one 30 centimeters in length; *Icaria cabeti* Saussure, another Australian species, makes a ball-like nest, a rather small replica of the well-known hornet's (*Vespa*) nest of the more-northern latitudes. In the Philippines are also naked combs of *Icaria* and others of this genus, covered over with an arched carton sheet which, when on the trunk of a tree, may greatly resemble the bark.

These insects, in common with tropical American *Polybia*, sometimes give off swarms which start a new household, although

a single female may also begin such a nest unaided. The severity of the sting is usually in proportion to the size of the wasp—a thing not greatly to be feared, nor yet much to be desired. Like most stinging wasps, *Icaria* is very beneficial in its other habits; the Australian *Icaria gregaria* Saussure often nests in the cane fields where it destroys, among other noxious insects, the sugarcane leaf-hopper (*Perkinsiella saccharicida*)³⁵ and various caterpillars.

Several nests of *Icaria cagayanensis* Ashmead were found in and about domiciles at Los Baños. In one case the colony was in a large bamboo upright; in another the nest was situated in the double sawale wall; while a third utilized a large crack formed by the imperfect splicing of a couple of large porch posts, the cells shut in from view by a papery cover.

While the dainty wasps of the genus *Stenogaster* (= *Ischnogaster*) are preëminently forest dwellers, some will occasionally build in outhouses in a woodsy environment. The rather common *Stenogaster depressigaster* Rohwer is one such, as is also a second species, whose nest only was found—several delicate cells strung in couples along a withered vine tip that had forced its way into the top of a small building.

The most noticeable of house wasps are the various mud daubers, representing the families Eumenidæ, Psammocharidæ, Sphecidæ, and Trypoxylonidæ. The Eumenidæ are related to the social wasps and, like the majority of these, keep their wings folded longitudinally in repose. Most of them provision their nests with the larvæ of moths; one Philippine species (*Odynerus luzonensis* Rohwer) preys upon the fat caterpillars of lycænid butterflies, while elsewhere others prey upon the young of certain beetles (*Anthonomus*, etc.) and the larvæ of sawflies (*Hymenoptera*). Eumenidæ that may be domiciliary are represented by eight or more species, with the orange-winged *Rhynchium atrum* Saussure perhaps the tamest and best known. Not gifted with architectural ability, she simply stores some suitable cavity—as within bambo furniture—with small, semiparalyzed caterpillars and plugs up the cells with mud. *Ancistrocerus domesticus* Williams and *Odynerus longitegulae* Williams are two yellow-and-black wasps of smaller size than *Rhynchium* that

³⁵ *Polybia occidentalis* Oliv., a small, yellow-and-black social wasp in British Guiana, is also a predator upon delphacid leaf hoppers, picking *Neomalaxa flava* Muir from the underside of the blades of a succulent grass.

occur about nipa houses at Los Baños, *Ancistrocerus* having been taken in the act of plastering up a nail hole in a box. These three wasps probably prey mainly upon microlepidopterous larvæ, but the wasps of the genus *Eumenes* are often found storing measuring worms (Geometridæ) in their juglike cells. These wasps are generally recognizable by their slender petiolate abdomen. At least two species, over an inch long (29 millimeters), and a third, smaller one are known to patronize Philippine nipa houses. *Eumenes curvata* Saussure is a fine, polished, black species, with iridescent purple wings and a slender waist, that is at home either in the house or in the forest. *Eumenes fulvipennis* Smith, of equal size but of duller appearance and with pale orange wings, is perhaps more partial to somewhat lower levels, although also a visitor, for nesting materials, to the muddy forest trails. These wasps exercise great circumspection in the choice of their home sites, which may sometimes appear to us as being in ludicrous situations. An egg is suspended in the neat, jug-shaped cell, which is forthwith stored with caterpillars (Noctuidæ, Notodontidæ), but more especially Geometridæ, or "looper" caterpillars stung to helplessness, this provender being carefully passed through the narrow cell opening by means of the wasp's jaws and first pair of legs; the jug is then stoppered with mud, its short mouth being also disfigured and the whole cell aggregate more or less muddled over into amorphism. *Eumenes fulvipennis* was found to prey upon semi-loopers (*Plusia*?) and on Geometridæ, or measuring worms. *Eumenes makilingi* sp. nov. is 14 or 15 millimeters long, black with some yellow marks; its neat little jugs are often found suspended from the loose end of a rattan thong or shredded nipa shingle, beneath a roof. I have not found such cells massed together as in the other two species, though they are deprived of some of their symmetry when stored (Plate 3, fig. 6).

Before leaving the Eumenidæ, attention must be called to the gum-nesting *Odynerus* (*Leionotus*) *xanthozonatus* Ashmead which, while not a mud dauber, is best treated here. This compact little wasp measures 8 to 9 millimeters long, and for a Philippine *Odynerus* has the black ground color strongly predominating over the pale yellow markings. She flies in a brisk manner, and when nearby with a fairly audible hum, and is not afraid to explore the darker places in a nipa house. She has the rather exceptional habit, among the Odyneri, of using a gummy material with a little sand or a sandlike substance intermixed, instead of the ordinary clay for constructing her cells. An ad-

ditional peculiarity of this species is the fact that frequently, if not as a rule, the female passes the night, and also dull daylight hours, in one of her cells. Such a cell is rather elongate, and narrowed and slightly curved at the mouth and, being of comparatively large size, affords plenty of space for the wasp, her egg or young larva, and for some of the caterpillar provender. She likes to build within houses and seems to be on the wing, though in varied numbers, throughout the year. I found but three nests or cell groups; secluded spots are chosen, and a row of six horizontal cells glued on the underside of a light table and shared by two wasps during June and July, 1921, furnished most of the data. Another nest was built in an old mud-wasp cell in a hole in a house post, while a third fitted the angle of two walls. The cells are provisioned with small, paralyzed moth caterpillars, which may be of several species, and are "passed" into the cell, the wasp facing the aperture and using the forelegs and probably also the mandibles in the operation. A single egg is fastened by a short filament to the wall at the end of each cell, and the young grub (Plate 3, fig. 2) feeds on the caterpillars within its reach, at first in a suspended position, but soon drops in among them and in a few days consumes the lot. The grub may be a day or more old before the mother seals up the cell by making a wet-looking, gum-and-grain disk. Two pupæ that I reared took about twenty days to develop into mature wasps.

During March, 1922, one of these *Odynerus* was observed preying upon the partly grown larva of a small moth that disfigures and rolls up the shining young leaves of *Eugenia jambolana* (Java plum) on the grounds of the College of Agriculture. The spry young caterpillar, in attempting to escape from one end of its rolled-leaf retreat, is usually seized in the jaws of the alertly pivoting wasp, and then is more or less paralyzed by stinging and carried nestward.

This species is of interest in constituting one of the ever-increasing array of solitary wasps known to throw some light on the origin of the social habits among the Hymenoptera. She has something in common with the large black *Zethus cyanopterus* of the Philippines,³⁶ although she does not partly masticate the caterpillar prey so that the tender wasp grub may more easily devour it, nor wait until this grub is full-fed before closing up her cell. Although these *Odynerus* are not friendly to one

³⁶ See Williams, in Philippine wasp studies, Bull. Haw. Sugar Planters' Assoc. Exp. Sta. Ent. Ser. 14 (1919) 157 et seq.

another, they may nest side by side with their cells in contact. This habit recalls somewhat the compound nest of the South American *Zethuscus lobulatus* Saussure, where each wasp has her own cells.³⁷ Evidence points to the cells of *Odynerus xanthozonatus* being cleaned of débris for further use. *Odynerus tropicalis* Saussure of Africa is more advanced than *Odynerus xanthozonatus*, in that she tends her young until full-fed and frequently nurses several young at one time.³⁸

The mud-daubing psammocharid wasps (Pseudageniæ) that may frequent houses are represented by several species that are often far more secretive in their nesting habits than are the Eumenidæ. The large black *Macromeris violacea* Lepeletier, with iridescent, violet-black wings, while occasionally entering dwellings in search of the large, active crab spider (*Heteropoda regia* Fabricius), is more a denizen of trees, in the hollows of which she usually constructs her shapely oblique cells. *Ageniella unifasciata* (Ashmead) very often builds her row of mud cells in plain view on some wall, whereas a larger species of *Pseudagenia* plunges mud-laden into a large and perforated bamboo wall support, so that an inspection of her nest is rendered impracticable.

Many kinds of spiders seek food and refuge within the nipa house, although the shelter thus afforded is not in every case all that could be desired. *Psammochares analis* (Fabricius), a medium-sized black wasp with clear wings and the abdomen tipped with orange, sometimes invades such houses in search of

³⁷ See A. Ducke, Zool. Jahrb. Syst. 36 (1914).

Here also may be mentioned *Montezumia infundibuliformis* (Fabricius), whose habits were observed in the lowlands of British Guiana during late 1923. It is a rather large black and brown wasp with transparent wings that attaches its mud cells to the trunks or limbs of trees or to other vegetation. These cells are comparatively large and thick, but the short, curved neck and the slightly flaring-lipped mouth are more delicate. The wasp egg is about 4 millimeters long and is fastened to the cell wall by a filament less than a millimeter in length. The store consists of small moth caterpillars, paralyzed and unmutated, and these, at least for the earlier part of its life, are fed periodically to the wasp grub. The mother wasp eventually seals the cell with mud; hatched cells may be used over again, the emergence hole being enlarged and lipped anew. Two females may occupy cells side by side, as was noted in a row of five contiguous cells, passing the night head outward in the commodious chambers that also harbored young wasp grubs and their food.

³⁸ Bequaert, J., Vespidae of the Belgian Congo, Bull. Am. Mus. Nat. Hist. 29 (1918) 185, 186.

crab spiders, probably closely related to *Heteropoda*. One afternoon in November, 1921, something was heard to fall to the floor from the ceiling of my room, and on looking down I beheld an *analís* wasp battling with a medium large spider that, finally managing to get upon its own back, strove to repulse the gingerly active hymenopteron with its nimble legs; the wasp, however, soon stung it to paralysis, fed (?) at its juices, and after a few short flights dragged it away, presumably to her nest under the house. *Psammochares analís* is not a mud dauber, but excavates funnellike depressions in the loose soil, storing each with a parasitized spider.

Four species of the familiar sceliphronine (Sphecidae) mud daubers nest within Philippine houses. All are spider catchers, storing many victims in each cell. *Chalybion violaceum* (Fabricius), while the most showy in a garb of metallic blue, is the poorest architect of the lot; it is perhaps more domiciliary than the others and in season abundantly evident on bamboo porch railings, etc. The female selects a convenient nest cavity, such as a nail hole, an old nest of one of its relatives, the hollow of a spool, penholder, chair-rung socket, etc., stores it with spiders and, laying an egg on one of them, stops up this cell with moist earth, which is covered over with a mixture formed in part of the excreta of some small animals, in this case of lizards. The cocoon period may be of some months' duration. *Chalybion* passes the night and unfavorable weather on a carefully selected object—in one case, several patronized the loop of some brown string suspended from a porch; this roost was finally abandoned, probably because of ants, the bane of wasps.

Of the three species of *Sceliphron*, the small *S. conspicillatum* (Costa) (*madraspatanum* of Bull. 14) is the tamest. It seems addicted to the lowlands, while *Sceliphron deformis* (Smith) and *luzonensis* Rohwer (= *interudens* of Bull. 14) are often seen in the forest. *Sceliphron deformis* is very common in some houses, where it ordinarily constructs its barrel-shaped cells within the bamboo walls. *Sceliphron luzonensis*, less frequent and of larger size, is a more-circumspect insect, often securing her massive ball-like mud nest far out of reach on some vine, wire, palm leaf, etc. She spends considerable time in exterior decorating, working upon her apparently completed nest for days and days.³⁹

³⁹ Kohl in his work on *Sceliphron*, Ann. Naturhist. Hofmus. 32 (1918), devotes about twenty-eight pages to the life histories of these wasps.

The wasps of the family Trypoxylonidæ in the Philippines are the long slender species of *Trypoxylon*, and the rather thick-set *Pison*. There are several kinds of *Trypoxylon* about Los Baños, and they are familiar insects, mud gathering on the forest trails of Mount Maquiling. Very few observations were made on the household activities of this genus but it is known that at least one small species sometimes nests in holes in house posts. Two or three species of *Trypoxylon* wasps, observed biologically in the Philippines, simply partition off preëxisting cavities with mud to make cells which they provision with spiders. Some of the American species are no better architects than these oriental ones, but there are others of the former that make very delicate and attractive nests. Many of the Trypoxylonidæ lend themselves easily to transportation in commerce; it is not surprising, then, that the little *Trypoxylon philippinensis* Ashmead has reached the Hawaiian Islands, where it very commonly nests indoors. So too with *Pison*; both *P. argentatum* Sh. and *iridipennis* Smith occur in the Philippines as well as in Hawaii, the former often constructing little flagreed mud cells arranged in a cluster upon some root, or lodged consecutively in some angle of a building. A *P. iridipennis* was found nesting in a hole in timber, as was also *P. lagunae* Ashmead, a shining and coarsely punctured little wasp. All hunt spiders, stuffing a number in each cell.

There are other wasps, mainly of small size, that frequent nipa houses, very often taking advantage of the cylindrical borings of post-and-bamboo beetles (largely of the families Bostrychidæ and Scolytidæ) for nesting places. One such wasp species, sometimes abundant on a beetle-perforated arigue in a sunny exposure, is the little black *Polemistus luzonensis* Rohwer, 1919 (Pemphredonidæ), measuring about 5.5 millimeters long and with a strongly sculptured head and thorax. Numbers of these insects, presumably males, may sometimes be observed flying up and down a post as if seeking the opposite sex. *Polemistus* preys upon aphids, or plant lice, and what is almost certainly this wasp is sometimes to be seen searching the figs of the common lowland *Ficus nota*, for the active, pale green to brownish, little plant louse that hides and feeds at the more or less protected bases of the crowded fruits. The wasp flies about such figs, finally alights upon one of them and carefully approaches her prey, as if in full knowledge that it has some natural means of defense, for she may stop and falter in her pursuit, evidently

repulsed by some scent or fluid given out by the posterior cornicles; the aroused aphids, on their part, hurry to the base of the fig but sooner or later one of them is suddenly seized by the fore end and immediately borne off nestward. Here is a post, punctured shotlike, with little beetle borings, some of which now serve as *Polemistus* nests, for occasionally a female wasp perches, aphis-laden, at a hole and, this being too narrow to admit both wasp and aphid simultaneously, the feebly living provender is placed at the entrance and apparently pushed within, the wasp following. Sometimes, however, she backs in to tuck in her prey with the tip of her abdomen. When fully stored, the boring is sealed flush with the surface with a translucent, resinlike substance. This insect is not without its enemies, the most-conspicuous one being a large handsome metallic green chalcid wasp (*Ecdamua* sp.), with an ovipositor that may exceed 16 millimeters in length or over three times as long as the remainder of the insect; with this implement she pierces the sealed *Polemistus* nest to parasitize the cell contents. Such are the bare observations on this chalcid.

A stout and alert little fly (*Milichiella*), nearly all blackish in the female but in the male with a satiny white abdomen, was very often seen on this particular porch post; but its business there, further than that it often investigated the little beetle holes therein, and before sundown backed for a millimeter or two into one of these holes, was not ascertained.

The family Crabronidæ contains a varied assortment of large-headed wasps that in the main store their nests with flies. Several species nest or hunt about nipa houses. *Crabro maki-lingi* sp. nov. is a rather stout insect, about 6.5 millimeters long, that stores small flies (in the case observed) in a deserted termite tunnel in a bamboo upright forming a house support. The genus *Rhopalum* is made up of small slender wasps with pediciled abdomen, that often tunnel pithy brambles or old stumps. Some species store aphids or spiders, and the Peckhams⁴⁰ studied two species that provisioned their nests with small gnats. This habit of storing midges—in this case, of the families Mycetophilidæ and Cecidomyidæ—was also observed by Nielsen with *Rhopalum clavipes* in Europe.⁴¹ This

⁴⁰ Instincts and habits of the solitary wasps, Bull. Scientific Ser. I, Wis. Geol. & Nat. Hist. Surv. 2 (1898).

⁴¹ Videnskap. Meddel. fra den Naturh. Foren. 1 Kyoenharm (1900) 262.

insect, however, has a diversity of tastes, for Bouwman⁴² found *Crabro* (*Rhopalum*) *clavipes* storing *Psocus bifasciatus* (Corrodentia); likewise, I noted the Philippine *Rhopalum domesticum* sp. nov. capturing insects of the latter group. For several weeks one or two males of this little wasp were noticed flying up and down a certain portion of a veranda post, and at times making an exceedingly brief stop on its surface. Several of this sex were captured and it was presumed that their localized movements concerned the female, perhaps to issue from a beetle boring in the post. On January 12, 1922, on a porch post opposite the first, a large area was webbed or sheeted over by a colony of Corrodentia, or "book lice," over which hovered a female *Rhopalum domesticum*, and when thus on the wing attempted to snatch up a victim; but here her efforts were fruitless, for the silken web protected the colony beneath from such haphazard aggression. Finally, however, the wasp alighted on the web and succeeded in biting a hole through it and had nearly pulled out a victim when, for fear of losing her, I captured her.

The very small larriid wasps belonging to the genera *Nitela* and *Rhinonitela* (Williams, 1927), being nesters in holes in wood, can be found on the outermost parts of buildings. *Nitela bicornis* Williams and *Rhinonitela domestica* Williams⁴³ were taken on veranda posts, and one or the other of these species was pulling a bit of dried soil, presumably to plug her nest hole. *Nitela* sp. is known to store plant lice and Corrodentia, or "book lice." Among the larger and typical Larriidæ *Dicranorhina luzonensis* Rohwer is an occasional visitor in rooms and quite addicted to running along the bamboo porch railing, window sills, etc. She nests, however, in the soil, often beneath a house on poles, and stores her burrow with little wood crickets. *Notogonidea subtessellata*, less bold than *Dicranorhina*, occasionally nests in flower-pots in outhouses; so also may a *Tachysphex* sp., in such earth containers on porches.

Of the fine big larriid wasp *Liris aurata* (Fabricius), plentiful in the Philippines, Maxwell-Lefroy says:⁴⁴

It is very often found haunting houses, especially store rooms, in search of house crickets. The latter are notorious domestic pests attacking provisions, etc. This wasp, in frequenting dwellings, performs the part of an efficient natural check on these domestic pests.

⁴² De levende Natuur. Amsterdam 16^s (1911) 176.

⁴³ Bull. Haw. Sugar Planters' Assoc. Exp. Sta. Ent. Ser. 19 (1927).

⁴⁴ Indian Insect Life (1909) 202.

Wasps of the genus *Chlorion* are typical, loud-buzzing Sphegidae that frequently attain a length of over 2.5 centimeters. They prey upon orthopterous insects, which they bury usually in the ground. *Chlorion aurulentus* (Fabricius) var. *ferrugineus* (Lepeletier) is the one of the several Philippine species of the genus observed by me that likes to hunt and even to nest and roost in the neighborhood of nipa houses. The short burrows of these wasps are to be found in the dry soil sheltered by the eaves, or in outhouses, and sometimes a female loudly inspects the nipa ceilings for the lurking brown grasshopper (*Gryllacris* sp.). These solitary wasps are not wholly without sociability, for they pass the night clinging, often in some numbers, to a bunch of dead leaves, or to seed pods. A piece of cord depending from the porch eaves made a satisfactory bed for one of these wasps, her blue mud-daubing relative *Chalybion violaceum*, and a large fly. The record dormitory consisted of a coarse ribbonlike band of straw about 2.5 centimeters wide and 30 long, hanging near a shower bath beneath a nipa house. One evening forty-two *Chlorion aurulentus* wasps were counted roosting on this strip. Such roosts are patronized night after night. Bedtime may be early in the afternoon, depending much on the kind of weather.

The Bethyliidae are all small, usually brownish to black wasps that generally prey upon the larvæ of beetles and of small moths. Five genera were found represented in houses at Los Baños, as follows: *Epyris*, *Desepyris*, *Perisierola*, *Sclerodermus*, and *Cephalomomyia*. These wasps make no nests and their presence in houses is to be explained by the fact that their prey frequently occurs in similar environment. A fat-bodied, wingless female of *Sclerodermus immigrans* Bridwell, of insignificant size will rarely find her way—probably by falling from the ceiling—upon one's person and inflict a sharp little sting. This insect almost certainly parasitizes the grub of one of the "bucbuc" beetles (Bostrychidae or Scolytidae) that may seriously injure bamboo structures by their perforations and which attack other woods as well. *Sclerodermus immigrans* Bridwell,⁴⁵ described by him from the Hawaiian Islands⁴⁶ and also iden-

⁴⁵ Proc. Haw. Ent. Soc. 3 (1918) 484, 485.

⁴⁶ Because of its close alliance with certain other species, Timberlake, Bull. Bishop Museum 31 (1926) 19, is inclined to regard *S. immigrans* as an endemic Hawaiian species.

tified by him from Philippine material ⁴⁷ was found by Bridwell on the lowlands of Oahu breeding on various coleopterous larvæ, whereas his researches, among others, show that the endemic Hawaiian *Sclerodermus* attacks chiefly wood-boring moth caterpillars.

The genus *Sclerodermus* also occurs in houses of bamboo structure in the Neotropics, as noted in Ecuador. *Cephalonomia* includes very small wasps. Bridwell ⁴⁸ found a Hawaiian species attacking the larva of *Hypothenemus*, a scolytid beetle that bores twigs. *Perisierola emigrata* Rohwer is a species inhabiting the Hawaiian Islands, which attacks small moth larvæ, including those of the pink bollworm (*Pectinophora gossypiella*).

The Chrysididæ, or cuckoo wasps, are very hard-shelled insects adorned with brilliant metallic, blue-green or ruby, that are parasitic in the nests of solitary wasps and bees, being very partial to the cells of mud daubers; they thus occur in houses. They do not defend themselves by stinging, but by curling up tightly. The largest Philippine species and the one commonly parasitizing the cells of *Rhynchium atrum*, the common household eumenid wasp, is *Stilbum cyanurum* Forster.

HOUSEHOLD BEES

The bees that may patronize Philippine houses are not so numerous in species as are the household wasps. In point of size the carpenter bees of the closely related genera *Mesotrichia* and *Xylocopa* are the largest. Probably more than one species tunnels house posts or beams, but the yellow-and-black *M. ghiliani* (Gribodo) at Lake Lanao, Mindanao, is the only one I observed frequenting houses.

CTENOPECTRA VAGANS Cockerell.

Castalia obsoleta Chevrolat is a rather large and handsome, purplish blue and red buprestid beetle that tunnels the wood, perhaps among other kinds, of *tamayuan* (*Strombosia philippinensis*), a valuable forest tree that occurs in the Mount Maquiling region, where it is often employed in buildings as arigues, or house posts. One such arigue, that was or had been thus infested, supported a corner of the roof and veranda of a house on the mountain slope. *Ctenoplectra vagans* Cockerell, a thick-set bee about 20 millimeters long, with a brilliant blue abdomen, was active about this post, as it utilized the deserted galleries

⁴⁷ Op. cit. 2: 291.

⁴⁸ Op. cit. 305-308.

of the beetle, while *Parevaspis abdominalis* Smith was more rarely seen; the latter is a less swift, nude-looking bee with a red abdomen, an undoubted parasite of *Ctenoplectra*. The late Dean C. F. Baker very kindly gave me one of his *Strombosia* arigues so that the timber could be split and sawed, and the interesting complex more thoroughly examined. The larva of the buprestid, like most of its kind, tunnels the wood chiefly along the grain and, having a much-flattened and widened thorax, makes a boring, oblong in cross section. It is a very slow-moving insect and obviously must feed for a long time in such a dry and innutritious medium before it can obtain sufficient food to complete its transformations. That part of the tunnel which turns off toward the exterior of the post and opens through it is in section subcylindrical, or a spherical triangle, for it represents the pupal chamber and the path of the differently shaped adult beetle in boring its way to freedom. It is this part in the main that affords good nesting places for bees and wasps; the bore fits *Ctenoplectra* and its parasite very well. These two bees are much alike in size and general shape, but even a cursory examination shows them to be very different in structure. *Ctenoplectra* somewhat recalls in color and size the familiar *Osmia*, spring bees of many temperate regions, and is highly modified in vestiture and legs for its special work; the other, with the red abdomen typical of many parasitic bees, is very sparsely hairy and has ordinary-looking legs quite unfitted for gathering pollen or nest materials.

During March, well along in the dry season, *Ctenoplectra* appears about certain house posts, zigzagging rapidly and with a high audible buzz while hurriedly searching for vacated borings. She alights before a tunnel, pokes in her head, withdraws it, and takes wing. A suitable hole is at last found, and presumably is cleared of any débris and, if necessary, made more cylindrical, not by additional boring in wood, but by filling in with or drilling through sawdust, the work of a beetle larva. In due time this tunnel is divided, as stored, into a few cells, the walls of which are commonly lined with a dark waxlike material. Each cell is supplied with well-packed, orange-colored pollen, which I suspect is gathered from the plentiful *Hibiscus* flowers nearby, an egg deposited on or near the provender, and the chamber stoppered with a plug of sawdust or earth, impregnated with the waxy or gumlike substance. In due time the egg hatches into a little larva which rapidly matures

on the pollen, spins a rather thin, brownish, tissuelike cocoon, and changes into a pupa in a few days; or the larva may enter upon a resting stage lasting several months, embracing winter and a part of the dry season. Then the larva loses its activity, becomes rather flaccid and yellow, and assumes a curled position, as do many other hymenopterous larvæ under similar conditions. With the coming of the warm season, bringing with it more available moisture, it changes into a pupa, in shape much like a mummified bee, with sawlike ridges between the segments on the back of the abdomen. The pupal stage is always short, and soon the perfect bee gnaws its way out to freedom. *Ctenoplectra* is nervously active and works rapidly. The deep orange pollen is pasted on to the outer surface of the broad hind tibia and first hind tarsal joint, both densely bristling with long, mixed simple and plumose hairs. It is this same apparatus that also carries grains of soil; the broad shearlike spur with its close-set comb teeth, and springing from the inner side of the hind tibiæ, no doubt helps detach a load and clean the outer tibial surface. A pollen-laden bee on arriving at her tunnel peeks into it, backs out, turns around, and then enters tail first.

The closing of the cell is an interesting operation. *Ctenoplectra* alights on the dry powdery soil, gathers some of it with the inner surface of the middle pair of legs—an examination of which indicates that it is the broadened, first tarsal joint, fittingly provided with well-arranged hairs, that performs this task—and transfers the load to the hind legs, now raised off the ground. She finally accumulates a noticeable load, carries it nestward, backs into the tunnel, and employs the hind legs as well as the abdomen in sealing the cell. If the cell be close to the surface, she can be seen tamping with the end of her body (which is provided beneath near the tip with divided rows of fine, soft, apparently glandular hair) and gradually meanwhile turning around so as to treat all the space. Perhaps the sticky material is carried on her hind legs, as their condition sometimes suggests, for they are rubbed against the walls of the cell which are finally wax (?) lined; the soft silky abdominal hairs may possibly also play a part here and secrete a sealing material. When the cap cover is in place it is noticeably moist.

A dispute over a tunnel may involve a tussle between two bees. A pollen-laden *Ctenoplectra* was seen to penetrate, head first and for half her length, a tunnel in which another of her species was lodged head outward; a brief tête-à-tête took place,

the outer bee first pulling back slowly and then with a jerk until her rival was completely hauled out; they held each other's mandibles and let go only when on the wing; the ousted bee immediately reentered the tunnel, the other one flying off.

The parasitic bee *Parevaspis abdominalis* inspects the arigue holes, occasionally entering one; apart from this, nothing was learned of its habits. Bingham⁴⁹ says: "*Parevaspis* is parasitic on the leaf cutter bees (*Megachile*). I have seen *P. abdominalis* entering the nest of *M. disjuncta*."

Another parasitic bee that sometimes patronizes house posts is a fat little black-and-yellow *Stelis* sp., which genus elsewhere is known to parasitize the nests of bees of the genera *Osmia* and *Dianthidium*.

A short-tongued, mainly black bee, *Prosopis luzonica* Cockerell,⁵⁰ is an occasional visitor to the veranda and may nest in holes in posts, and the little *Heriades sauteri philippinensis* Friese⁵⁰ is also a patron of nipa dwellings.

One or more leaf-cutter bees (*Megachile*) are to be expected in houses, using a suitable crevice in which to make their leaf-bit cells; in fact, one was discovered nesting in a rattan and bamboo chair in a room.

The social bees of the Philippines are represented by the genera *Apis*, *Bombus*, and *Trigona*. *Apis indica* merges into *A. mellifera* Linnæus, the common honey bee that is kept for its honey and wax and is rather widespread in the Islands. *Apis* (*Megapis*) *binghami* Cockerell and *dorsata* Fabricius are two much larger and "undomesticated" species. In India *Apis dorsata* is said to build its comb in and on various portions of buildings, such as in double walls, under wooden staircases, on marble arches, etc., and, being of a fierce and pertinacious disposition, often renders these buildings untenable.

Apis florea Fabricius is a rather small species that extends into the Malayan region at least as far as Java. Bingham (1897, p. 557) reports seeing a nest of this species "under the eaves of the roof of a forest bungalow."

Bumble bees (*Bombus*) dwell in the cool mountains.

Trigona biroi Friese belongs to a group of social bees usually of small size (hence the term "mosquito bees," sometimes applied to minute species), far better represented in tropical

⁴⁹ Fauna Brit. Ind., Hymenoptera 1 (1897) 499.

⁵⁰ Identified by T. D. A. Cockerell.

America than in the Orient; three species have been recorded from the Philippines.⁵¹ While incapable of stinging, some kinds can make themselves very disagreeable by getting into one's hair, particularly when their hind legs are laden with a gummy substance. The Philippine species in question is a small black one, 4 or 5 millimeters in length, that is widely distributed in the Islands and builds its nest in a variety of situations. In Dumaguete, Negros Island, I have seen a nest in the joint of a large bamboo, and it probably builds on occasion in favorable places in buildings. The meliponine bees, including the genus *Trigona*, may produce considerable honey. Their food habits, however, are not always cleanly.

HOUSEHOLD ANTS

As far as numbers are concerned, ants are an exceedingly successful group of insects, a fact particularly true in tropical regions. Some species exist only in a special environment, but others are adapted to a wide range of conditions and are thus found in houses, on shipboard, etc. The more-specialized forms and those incapable of a strong defense cannot, as do a number of other endemic insects, withstand encroachment by cosmopolitan species that invade their habitat. It would be quite out of place here to give even a brief account of the salient features of the life of ants, their variety, classification, etc. Only a few species that may live in or occasionally invade Philippine houses will be dealt with. Needless to say, ants are a great pest to man in the Tropics, and in the houses it is a matter of constant vigilance to keep them away from foodstuffs and other desiderata, and in some places it is distinctly uncomfortable to scale a tree without first taking its ant fauna into account.

The subfamily Dorylinæ includes the famous legionary, driver, and visiting ants that are particularly conspicuous in Africa, and South and Central America, some of the species of which often invade houses and rid them of vermin. They are therefore beneficial in their predatory habits, though their bites and stings are frequently severe. The females are large, sluggish, and very rarely found; the workers are active, blind, and of several sizes, the largest with immense mandibles; the males are winged, comparatively large and wasplike, with the eyes highly developed. The Philippine species observed sometimes paying the nipa house

⁵¹ Cockerell, T. D. A., Philip. Journ. Sci. 14 (1919) 77.

a brief visit belong to the genus *Aenictus*, rather small, wiry, blackish ants apparently with no major workers which, though blind, race along in very narrow and orderly columns in search of the nests of certain other ants—as do those of *Anoplolepis*, probably leaving the fiercer species alone—which they raid particularly for the sake of the young. These ants do not concern themselves with man's foodstuffs; but, after having attended strictly to their particular prey, soon leave the premises.

The Ponerinæ are a family of primitive ants that nest usually in comparatively small colonies. The larger species may sting severely. Most kinds live away from the habitations of man, but several large ones (*Odontomachus*, *Odontoponera*, and *Diacamma*) are able to endure a great deal of civilization. The species of *Diacamma* are usually blackish in the worker sex, with the very dissimilar males pale yellowish or yellowish red, and provided with wings and long antennæ. They nest in convenient hollows in trees, under bark, logs, etc., and cover the entrance over with a sort of curtain of interwoven débris. They are timid insects and easily repulsed by certain comparatively small species.

For some time a small colony of *Diacamma rugosum* Le Guill. subsp. *geometricum* Smith var. *viridipurpureum* Emery⁵² occupied a rather precarious nesting place in the extremity of a termite-eaten beam supporting the back of the porch of the old forestry building at Los Baños. For a while they held their own, but eventually vacated their dwelling, probably in favor of other ants. Their new habitation was soon discovered for, upon pushing my foot into a rather moist tennis shoe that had been left on the sunny porch to dry, I felt a sort of scrambling movement within. The shoe was hurriedly pulled off and a quantity of *Diacamma* dislodged. Both shoes were occupied by a total of about twenty of these large ants, with their larvæ, a cocoon, and a dead bug as provender. In one of the shoes a nest covering consisting of masses of dust, dry bits of leaf, etc., had already been made. The tennis shoes of two neighboring parties were similarly seized upon by these ingenious ants whose presence within was less agreeably hinted at than in my case, by a few effective stings in the pedal extremities. In *Diacamma*, as has been shown by Wheeler and Chapman⁵³ from

⁵² Identified by Wm. M. Wheeler.

⁵³ *Psyche* 29 (1922) 203–211, 4 figs.

a study of the Philippine *D. australe*, the egg-laying function is assumed by one of the workers, differing not at all from her fellows excepting that she is made capable of reproduction. The genus is peculiar to the Indo-Malayan and Australian regions.

The subfamily Myrmecinae has two nodes to the pedicel of the abdomen and embraces perhaps the most pestiferous and domiciliary of all ants. Many sting very efficiently as, for example, the "fire ant" (*Solenopsis gemminata*) and the agricultural ants (*Pogonomyrmex*). Some of the most annoying of Philippine ants are one or more species of *Phidologiton*, which live in immense communities and, despite the small size of the ordinary worker, bite very feelingly. It is this ant that one sees crossing forest paths in columns studded with the shining and comparatively immense "soldiers" and also patronizing the numerous decaying figs of *Ficus nota* on the lowlands. They nest rather deeply in the ground, sometimes beneath houses which they may so invade as occasionally to drive the occupants from their beds. They are both granivorous and insectivorous.

At least three species of *Tetramorium*, identified by Doctor Wheeler, frequent houses about Los Baños. They are *Tetramorium* sp. near *simillimum* Roger, *T. guineense* Fabricius var., and *T. pacificum* Mayr. One ant, probably of this genus, was never observed except in small numbers, dwelling in a knot hole or beetle boring in house posts. It had a sluggish, crouching gait and was fond of visiting one's tooth brush. When pressed and rubbed with the finger it finally breaks into three pieces. *Atopula ceylonica*,⁵⁴ related to *Tetramorium*, was found in the winged form in a house at Los Baños.

Tetraoponera attenuata F. Smith (*Sima attenuata* Smith) is a very slender, polished, black ant of wide Malayan distribution, that is occasionally found in houses, but which more commonly nests in twigs and other hollows in trees. The ants of this genus are powerful stingers and are mimicked by attenuated spiders and, in the case of *Sima rufonigra* Jerdon in India, by *Ampulex constanciae* Cameron, a sphecid wasp that preys on cockroaches.⁵⁵

The genus *Monomorium* contains some cosmopolitan species that very frequently infest houses, where by their small size they are able to gain entrance into very narrow spaces. No

⁵⁴ Identified by Wm. M. Wheeler.

⁵⁵ See Bingham, Fauna Brit. Ind., Hymenoptera 2 (1903) 110.

list of Philippine house-inhabiting species was made, though it is to be expected that *M. floricola* Jerdon var. *philippensis* Forel, *M. pharaonis* Linnæus, *M. destructor* Jerdon, and *M. minutum* Mayr may be listed here. *Phidole* and *Cremastogaster* should also occur in buildings.

The subfamily Dolichoderinæ has at least one disagreeable little black ant that is to be found particularly in vine-laden houses. *Dolichoderus* (*Hypoclinea*) *bituberculatus* (Mayr)⁵⁶ is a lover of honey dew and may be present in such numbers upon certain trees and bushes attending mealy bugs, tree hoppers (*Membracidæ*), etc., as to make the inspection of such plants very unpleasant. They do not sting but nip rather capably and squirt out a fluid smelling like rancid butter, from the end of the abdomen. They are found stringing along bamboo railings, arigues, and wires for the transmission of electricity. They are also about at night. They often rest (?) on the march and are then found in groups or camps along their pathway. Their nest may be located in a bamboo joint in a house, between two leaves fastened together by a sort of rough carton, etc. When disturbed they become very irascible and rush out of their nest and stand in a challenging manner, jaws open and body raised off the ground so as to bring the tip of the abdomen forward and up, to discharge the unpleasant fluid. Despite their aggressiveness, a certain tiny fly causes them much concern. Once I observed some of these ants carrying on in an aggravated manner, for the minute dipter was flying over and about an ant, now and then darting down and occasionally touching it, apparently on the thorax. The fly attempted to touch the same ant more than once. An attacked *Dolichoderus*, instead of moving along, at first assumed its offensive pose, with jaws wide open, and started angrily at each touch, but when the fly kept repeating its tactics the victim stampeded. Presumably this little fly parasitizes these ants.

The Camponotinæ include ants of very high mental and social order and species of such genera as *Formica*, the biology of which has been much studied in temperate regions.

Oecophylla smaragdina (Fabricius) lives in trees where, using its larvæ as spinners, it constructs a silk and leaf nest. It is a most decidedly unpleasantly biting ant that occasionally gets on porches through the medium of wires or vines. A

⁵⁶ Identified by Wm. M. Wheeler.

rather exhaustive account of this ant in India is given by Hingston.⁵⁷

*Anoplolepis longipes*⁵⁸ Jerdon is an active, long-legged, yellowish ant, commonly seen running about floors. It nests in old, eaten-out planks, between débris and plants, etc. Though of slight build it is able, through an anal fluid, to hold its own in the ant world and to prey upon comparatively large insects, such as winged termites.

Paratrechina longicornis Latreille are abundant, particularly in outhouses. They are inquisitive, rather small, very active blackish ants which, when flooded out of their outhouse abode, as by water from a hose, will scale the walls and there, high and dry, queens in their midst, wait until the danger is past.

The carpenter ants belong to the genus *Camponotus* and dwell chiefly in dead wood which they hollow out to some extent and often protect the more-exposed portion of the nest with a crude sheet of débris. They are rather large ants with two or more castes in the worker sex, one having very massive heads, and the other constituting effective defenders of the colony for, when disturbed, they rush out and fiercely pinch any offending object. In the Philippines, I have found *Camponotus* (*Tanaemyrmex*) *irritans* F. Smith subsp. *obfuscatus* Vieh⁵⁹ in a house, and it is probably the species that nested in old house timbers, remaining in seclusion during the day and sallying forth at night in search of food. Winged male and female *Camponotus* are often attracted in annoyingly large numbers at lights, sometimes, it seems, almost to the exclusion of other insects.

Additional species of ants are attracted to lights—here may be mentioned *Camponotus* (*Colobopsis*) *leonardi* Emery⁵⁹ and species of *Polyrhachis*. The latter genus is represented in the Philippines by many species, the majority of which inhabit the forest, where their nests of silk and débris are often found on trees. Some species, such as *Polyrhachis* (*Myrmhopla*) *acantha*⁵⁹ dwell in more-open country and are sometimes found in and about houses. The members of this genus are very commonly armed with a few more or less conspicuous spines.

⁵⁷ Journ. Bombay Nat. Hist. Soc. 29, Parts 1-3, 363 et seq.

⁵⁸ Identified by Wm. M. Wheeler.

⁵⁹ Identified by Wm. M. Wheeler.

DESCRIPTIONS OF NEW SPECIES OF WASPS

EUMENES MAKILINGI sp. nov. Plate 2, figs. 2 and 3.

Female, type.—Length to end of second abdominal segment, 13 millimeters. Slender. Black, with pale yellowish markings as follows: A pair of large, almost fused spots at base of clypeus, wedge between antennæ, inner eye margin from near base of clypeus to large part of emargination, narrow strip behind eyes, pronotum with a dorsal band, notched posteriorly in the middle, and with an adjoining lateral band on anterior margin, mesonotum with a lateral stripe anterior to the tegulæ and two pairs, one below the other on the pleuræ, small spot on posterior part of tegulæ and posterior angles of scutum, a pair of wide, more or less fused spots on metanotum, and two pairs of spots on propodeum, apex of fore and middle femora, and most of fore and middle tibiæ, mid and posterior coxæ on outer side, and a small dorsal stripe on hind tibia, dorsal apical margin of pedicel, spot each side second abdominal segment, a subapical band on second abdominal tergite, and a double spot near apex of second abdominal sternite; teeth and apex of mandibles reddish; wings moderately infusate. Generally smooth and polished; puncturation scattered and rather shallow, best developed on upper part of frons, on pronotum, mesopleuræ, propodeum, and second abdominal segment, the segments following sparsely and very finely punctate; clypeus gently emarginate, mandibles with four teeth, third joint of antenna nearly twice as long as fourth; thorax short, stout, rounded fore and aft, without processes, except the drawn-out posterior angle of scutum, propodeum bilobed by reason of the longitudinal foveate median line; pedicel slender, about equal in length to head plus thorax, the spiracle on a slight swelling at about middle length, second abdominal segment drawn out a little petioliform where it joins the petiole and raised ringlike on the yellow band before the thin, slightly reflexed posterior margin of tergite. Wings with the two recurrents entering the second submarginal cell about equally distant from the middle, second submarginal cell subtriangular, narrow along the marginal vein, third submarginal much larger than second. Vestiture: Some erect hair, white on face and sides of thorax, propodeum, and abdomen, pale brown on notum of thorax.

Male, allotype.—Length to end of second abdominal segment, 11.5 millimeters. Much like the female though more heavily and deeply punctured, particularly on thorax and with the clypeus entirely yellow except the gently emarginate apex and the entire eye margination yellow. Antennæ well hooked; spiracular tubercle on pedicel better developed than in the female.

Type, from Los Baños, Luzon, February, 1922; allotype, Zamboanga, Mindanao, October, 1921, *F. X. Williams*; paratypes, 2 males and 1 female, Los Baños, Luzon, *C. F. Baker*; 1 male, Los Baños, Luzon, 1925, *C. E. Pemberton*; and 1 female, Los Baños, Luzon, November, 1922, *F. X. Williams*.

In some specimens the thoracic bands are more or less interrupted.

ODYNERUS LONGITEGULAE sp. nov. Plate 6, figs. 2 and 4.

Female, type.—Length to end of second abdominal tergite, 10 millimeters. Of medium build. Black and polished; yellow as follows: Clypeus (except a median stripe and front margins), base of mandibles, scape beneath, small spot between antennæ and a large one just above this spot, invagination of eyes and a stripe on cheeks, front of pronotum, a pair of hooklike markings (recurved outwardly) on scutum, tegulæ except submedian spot and margin, a large spot on sides beneath wings, two spots on scutellum and most of mesonotum, apical sides of propodeum, forelegs, except most of trochanters and of coxæ and part of femora, the second and third pairs of legs less yellow but more brownish; wings lightly infusate, abdomen with a band on first four segments, a pair of lateral spots on first segment; in addition, the mandibles are mainly brownish, of which there is also a good deal on the legs, and the spot and margin of the tegulæ are pale semitransparent brown. Head about as wide as thorax; mandibles 5-dentate, the fifth or basal tooth from lower side of fourth; antennæ with joint 3 distinctly longer than 4; clypeus nearly or quite as long as wide, the distal produced part truncate and slightly emarginate; between the bases of antennæ the frons is longitudinally raised and finely carinate in the middle, sculpture of deep, rather large punctures, though the disk of clypeus is medially more or less irregularly longitudinally wrinkled; punctures very close on frons, tegulæ especially elongate; the propodeum has three teeth at its latero-apical angles, the uppermost tooth giving forth a delicate carina that runs back toward base, the sides of propodeum in a great measure of exceedingly fine reticulate appearance and

with some wrinkles at sides, posterior face with trace of fine median carina and fine, not very distinct, oblique striæ; wings with marginal cell rounded from apex and slightly appendiculate; abdominal segments 2, 3, and 4 particularly strongly punctured, especially at apex where the punctures are rather deep, margin of second tergite well reflexed. The transverse furrow on second sternite is not carinate but more or less punctured, while mesially from its posterior edge runs a short impressed line. Vestiture sparse, mainly silvery golden pubescence.

Type, 1 female, from Los Baños, Philippines, June, 1917; paratype, 1 female, same locality, June, 1921, *F. X. Williams*.

The paratype lacks the small spots on the first abdominal tergite but has a pair of small spots on the second sternite. The first abdominal tergite is also less strongly reflexed.

This insect has somewhat the appearance of *Odynerus ves-poides* Williams (1919), which has the marginal cell likewise somewhat rounded apically and slightly appendiculate.

ODYNERUS (LEIONOTUS) XANTHOZONATUS Ashmead. Plate 6, figs. 1 and 3.

Odynerus (Leionotus) xanthozonatus ASHMEAD, Proc. U. S. Nat. Mus. 28 (1905) 962.

The male is much like the female; the antennæ are hooked at the tip, and additional yellow markings are as follows: Basal curvature of clypeus (instead of merely both basal sides), stripe on first antennal joint beneath, and the tarsi, more or less basally. The mandibles have four teeth; and the median pit or depression behind the ocelli, which in the female has a raised and arched posterior border, is here subobsolete.

This insect has a fondness for building in and about dwellings of the more open type, and the nest-building material is mainly a resinous substance.

ANCISTROCERUS DOMESTICUS sp. nov. Plate 6, fig. 6.

Female, type.—Length to end of second and abdominal tergite, 7 millimeters. Moderately slender; black and polished; yellow as follows: Clypeus, mandibles, first two antennal joints, spot between antennæ, within eye emargination, back of the eyes above, two spots on pronotum, tegulæ, posterior scutal angles, metanotum, legs except coxæ and trochanters and portion of the hind femora, posterior margin of first abdominal tergite, and both tergite and sternite of second abdominal segment; flagellum of antennæ brown beneath; wings lightly infusate. Head

about as wide as the middle of the thorax, squarish behind the eyes; mandibles (with tip broken) probably 5-dentate; antennæ with joint 3 distinctly longer than 4, the flagellum clavate; clypeus nearly or quite as long as wide, the distal truncation gently excavate; between the eyes at the base of the clypeus the frons is longitudinally swollen and sharply carinate for its distal portion; elsewhere the frons and genæ are very closely and rather coarsely punctured (= reticulate); the vertex, particularly the ocellar area, has much finer and sparser punctures, with the occiput with large separate punctures; ocelli but little sunken, arranged in a low triangle and posterior to them a small median pit. Thorax coarsely and closely punctured with a reticulate effect; posterior face of propodeum excavate, with a fine median carina and mainly with sparse scattered punctures except dorsally and down the sides where it is deeply reticulate; drawn out into a pair of thorns at the sides and near the base and with a still more basal place; second submarginal cell nearly triangular and receiving the second recurrent quite near its outer edge; third pair of coxæ with a flat thorn on the postero-lateral angle. Abdomen with two transverse carinæ on basal half of first tergite; transverse notch in second abdominal sternite with 10 or 11 longitudinal carinulæ, posterior to this sternite it is rather suddenly and well raised. Abdomen with rather scattered though distinct punctures above and below, at least on the first three segments—the other segments being well retracted. Vestiture, very sparse and yellowish.

Described from 1 female that was plastering up a nail hole in a box in a house. Los Baños, Philippines, March, 1921, *F. X. Williams*.

This may be the female of *Odynerus imbecillius* Saussure, from Java.

CRABRO MAKILINGI sp. nov. Plate 6, fig. 8.

Female, type.—Length, 6.5 millimeters. Rather stout, except that abdomen is subpetiolate. Black, with yellow as follows: First antennal joint, raised posterior pronotal ridge (reddened by cyanide?) and the lobes, scutellum (also with two brown spots), and a large part of the tibiæ and tarsi; the mandibles largely reddish, while a part of the antennæ and the tegulæ are brownish. Sculpture delicate. Mandibles bidentate at apex; clypeus subtruncate and gently trilobed at apex, a central carina not attaining margin; antennal sockets

touching each other and, outwardly, the eye margins, joints 2 and 3 about equal, 4 longer; eyes widely diverging toward and subemarginate at vertex; ocelli in a low triangle, the anterior ocellus the smallest and separated from the others by a little less than its diameter, the posterior ones distant from the compound eyes by about the diameter of each; head shining and with very fine separated punctures; mesonotum and metanotum with rather fine separate punctures, denser anteriorly on scutum; propodeum more polished and only weakly punctured and with a weak initial basal carina, a well-marked posterior fovea and a fine bounding carina on sides, a fine transverse carina on sides before mid coxa. Wings with truncation of marginal cell a little oblique, first recurrent vein joining first submarginal cell very slightly before middle. Abdomen with the first segment forming a short petiole, with fine, well-separated punctures and the sides finely keeled to apex; pygidium subtriangular, about as long as wide, compressed, though not finely drawn out nor excavate at apex, the lateral margins low, a well-defined median carina, the disk rather dull and coriaceous. Vestiture, silvery pile on the clypeus.

Type, 1 female, Los Baños, Philippines, September 9, 1917, *F. X. Williams*; nesting in an old termite tunnel in wood and storing flies. Paratypes, 3 females, same locality, July and August, 1921. The paratypes have no brown on scutellum.

RHOPALUM DOMESTICUM sp. nov. Plate 6, figs. 5 and 7.

Female, type.—Length, 5 millimeters. Slender; polished and black, with yellowish white as follows: First antennal joint, lobes of pronotum (except spot), tegulæ in part, first and second pairs of legs, apical part of hind coxæ, trochanters and base of tibiæ of hind legs, and basal part of pedicel of abdomen; mandibles largely reddish and flagellum and apex of abdominal segments brownish, with posterior margin of pronotum more or less testaceous. Mandibles bidentate at apex; clypeus with a prominent lobe on each side of middle, and with lateral angles sharp; a median beaklike process just above and against antennal sockets; frons smooth, narrow, and excavate for the antennæ; antennal joint 2 longer than 3, which is a very little less than 4; eyes strongly diverging toward vertex; ocelli arranged nearly in an equilateral triangle, the fore ocellus a little the smallest, all separated from one another by less than their diameter, and from the compound eyes by more than their diameter; a fine impressed line from each posterior ocellus to

eyes; vertex and thorax with fine separate punctures; propodeum almost without punctures, a few basal carinulae, a posterior face fovea, and below it toward pedicel a carina and some transverse carinulae; marginal cell obliquely truncate; first recurrent vein running into first submarginal cell beyond middle; abdomen finely coriaceous. Vestiture, silvery on clypeus.

Male, allotype.—Length, 4.5 millimeters. Like female, except clypeus, which is subtruncate with the lobes very much reduced, thus forming rounded outer angles, and a shallow median excavation, lateral angles not so prominent.

Type, 1 female, Los Baños, Philippines, January 12, 1922; allotype, male, same locality, September 10, 1922; paratypes, 4 males, same locality, June and August, 1921, *F. X. Williams*. Preys on Corrodentia (book lice).

COLEOPTERA

BEETLES

HOUSEHOLD BEETLES

Unfortunately, not much attention was given this order of insects as occurring in dwellings, although they exist there in considerable variety. Large numbers may be attracted to lights, causing some annoyance by their erratic gyratory flight. After the lights are turned off, flashing fireflies (*Lampyridae*) are often seen high under the dark apex of the roof. At least several species may thus occur in houses, a common one with a strong luminescence being *Colophonotia praeusta* Eschscholtz, a pale brownish insect 7 or 8 millimeters long; another is a species of *Luciola*, of lesser size and with black elytra, while a third is *Vesta* sp., rather large and wide, red and black, and but feebly luminescent. Outside in the fields by the roadside or along the river additional species occur, and one may come upon a beautiful sight in a wayside tree fairly scintillating with their numbers. As adults, certain fireflies are carnivorous, but many of the more delicately formed kinds are undoubtedly plant feeders, wholly or in part. The larvæ prefer moist places, and the Los Baños ones are common along Molawin River, a small stream arising from the slopes of Mount Maquiling. Their luminescence is usually inferior to that of the mature insect. Snails form the principal food of many of the larvæ (that is, those with a slender form and greatly extrusible head), and they do

not confine their hunt to the ground but may be found on some bush as well, the head and part of the thorax inserted into the shell of the victim (Plate 3, fig. 5), which they paralyze with a single nip of the jaws.

Of very commonplace aspect but of great economic detriment are the *bucbuc*, the Tagalog name for certain boring beetles of small size, generally belonging to the families Bostrychidæ and Scolytidæ. These are stout cylindrical insects with rounded or subtruncate extremities that form their "shot-hole" tunnels in wood, both as young and as adults. The bucbuc that perforate the bamboo work of a house, particularly when this wood is not well seasoned, are especially injurious, as the quantity of wood dust beneath the attacked portions indicates.

Dinoderus minutus (Fabricius)⁶⁰ are among the chief "shot-hole" offenders, and they quickly ruined some long straight pieces of stem of *Schizostachyum lima* bamboo that I had brought into my room. Their borings were 1.5 millimeters in diameter and about 35 long. Woodworth⁶¹ mentions three Bostrychidæ; namely, *Dinoderus brevis* Horn, *Dinoderus minutus* Fabricius, and *Heterobostrychus aequalis* Waterhouse, as attacking species of bamboo. Other beetles, such as the larger *Xylothrips flavipes* Illiger (Bostrychidæ) and Scolytidæ, attack the posts, or arigues, of forest timber. A species of domiciliary *Sclerodermus*, a small wasp, wingless and antlike in the female sex, no doubt parasitizes the larvæ of the lesser bucbuc, while the much larger *Xylothrips* seems to have an enemy in the slender metallic blue beetle (*Cylidrus cyaneus* Fabricius) of the predatory family Cleridæ, which may from time to time be seen entering beetle borings in posts; here belongs also *Tillus someranus* (Gorham), a red and black species often common in houses and on house posts, and the cosmopolitan *Tarsostenus univittatus* (Rossi).

The still larger bostrychid *Heterobostrychus aequalis* Waterhouse sometimes breeds in the wood of boxes, and has been taken thus in Manila.⁶²

At least two species of powder-post beetle, *Lyctus* sp. and *Minthea rugicollis* Walker of the family Lyctidæ, occur in Phil-

⁶⁰ Identified by F. C. Hadden.

⁶¹ Philip. Agr. 10 (1921) 13.

⁶² *Heterobostrychus aequalis* and *Dinoderus brevis* have been reared from bamboo shipped into England. Tomlin, Ent. Mo. Mag. III 11 (1925) 94.

ippine houses and, if we include insects affecting stored products, a number of other beetles will be added to the list.⁶³

PRIONOCERUS CAERULEIPENNIS Perty. Plate 2, figs. 4, 5, and 6.

The family Melyridæ is closely allied to the Malacodermidæ, which contains the majority of luminescent beetles. It is not surprising, therefore, to find that the power of producing light is not wholly lacking in the Melyridæ, as exemplified by the common *Prionocerus caeruleipennis* Perty (Plate 2, fig. 4) of the Philippines and elsewhere. The beetle in question is 10 to 12 millimeters in length, with a reddish pronotum, and deep metallic blue to greenish wing cases. Perhaps fully matured specimens are nonluminous, but larvæ, pupæ and, to a slight extent, callow adults are light-bearing. My first acquaintance with the luminescent property in *Prionocerus* was the finding at dusk of its rather elateroid, prong-tailed larva, on November 8, 1920, in a ravine. Some weeks later, one evening after retiring I noticed a shining spot on the coat rack in my room and, on examining a suspended garment there the following morning, found an actively wriggling *Prionocerus* pupa hanging from the shrunken larval skin that was loosely secured to the coat. It yielded an imperfect adult. Rather well-grown larvæ (Plate 2, fig. 5) were found in the evening near Molawin Creek, Mount Maquiling, Los Baños, where they occurred as a rule on pieces of wood and twigs. The body is rather stout and depressed and the large head bears a pair of strong jaws that suggest a carnivorous habit. The fore part of the head is rich brown, the base pale brownish white, with a curved line across it; the main part of the body above is a sort of wood brown; the anal process is forked and roughened and blackish brown in contrast to its whitish base and preceding segment. The body has sparse erect pale brown hairs. The larvæ, one of which was 15 millimeters long, are active and with greenish luminescence distributed as follows: A rather diffused lateral spot on the mesothorax and methathorax, a large strong spot on each side of the eighth abdominal segment, and segments 5, 6, and 7 have two pairs each, the upper small and more anterior as well; 4 has one upper spot, and 3, 2, and 1 of abdomen each a pair of spots rather low on the sides. The pupa (Plate 2, fig. 6) at first showed a greenish yellow glow throughout the body with the head more strongly luminous, but as it approached ad-

⁶³ See Woodworth, Philip. Agr. 10 (1921) 35.

olescence only the head end and the sides of the abdomen shone, the rest being dark or nearly so. Five days after its discovery it was still luminous in its head and tail portions but more distinctly so toward the head where there were two lateral prothoracic and one basal, pronotal area. The freshly hatched adult is only faintly luminous, the glow best developed on the prothorax, back of the wings, and a little on the abdomen.

The adults appear to be phytophagous, a number having been seen nibbling the anthers on the inflorescence of a palm tree.

VERTEBRATES

FROGS IN HOUSES

POLYPEDATES LEUCOMYSTAX Gravenhorst. The banana frog, *palacang saguing*. Plate 7, fig. 3; Plate 8, fig. 4.

This common and widely distributed frog is known to almost everyone who lives away from the madding throng. It resembles in form and in some of its habits its smaller relatives, the pretty green or brown tree toads (*Hyla*) of the United States. A good-sized banana frog is about 7.5 centimeters long in head and body and, though varying in color, is usually a sort of olive brown with darker body stripes. It is much less timid than are many frogs and not very aquatic.

It is an expert climber and likes to rest in the shade on leaves of large size, like those of the banana, the Manila hemp, or abacá (*Musa textilis* Née), and heliconoids, and is not averse to selecting a cozy place in a house as a temporary habitat. One of these amphibians chose the damp folds of a bathing suit hung upon a bamboo pole on a porch of western exposure, as a fitting place in which to cool off. At night it becomes active, and after contemplation moves along in 1.5-meter leaps, jumping very quickly in through the open door and on the wall or table. It may rest for some minutes on the vertical woven bamboo wall. No doubt it is attracted by the insects that fly to light. Its croak is dry, rather harsh and suppressed, and not very loud. The eggs are enveloped in a mass of foam which becomes hard-crusting in the sun; these masses are suspended from twigs, leaves, stones, etc., over or above water, and I found many such plastered on the cement walls of a water trough; some of the masses just reached down to the water, some were partly immersed, and others still well above it. The tadpoles, on hatching about three days later, have only to wiggle down by gravity to the lower edge of the white mass, break through it, and drop into the water

and there complete their transformation. In the frothy egg masses are often found the maggots and puparia of a good-sized muscoid fly.

Polypedates leucomystax has a representative, perhaps more domiciliary than itself, in North Queensland, Australia. It is *Hyla caerulea*, a green frog (despite its specific name) that reaches a length of 10 centimeters. Its snout is blunter than that of the banana frog and it seems less active. It was rather numerous about the veranda of the house where I lived for a couple of months, and toward evening several would leave their place of concealment between or on top of the shaded beams, and either crawl about the house posts in a series of pausing advances, or else surprise one by the loud "plop" of their leap from on high to the cement floor. I was told that this frog, which at certain times of the year often roosts in houses or about porches in considerable numbers, inflates itself preparatory to its fall! When alarmed or seized by its natural enemies it gives forth a shrill and startling cackle, evidently calculated to confuse its foe.

According to Taylor,⁶⁴ over fifty species of the genus *Polypedates* are known, and seven of these have been recorded from the Philippines.

LIZARDS IN HOUSES

Lizards are among the most-constant representatives in a tropical house fauna. Some, as the skinks, are common only in country places, and even then can scarcely be called domiciliary, but many of the Geckonidæ are satisfied to spend a lifetime in buildings where conditions are favorable to their existence.

Foremost in size and reputation among the Philippine Geckonidæ and a veritable surprise to the new traveler in the oriental Tropics is the "talking lizard" or *tukko-tukko* (*Gekko gekko*) of the Filipinos. This reptile, the ruler of the ridge pole (Plate 3, fig. 10), is perhaps more often heard than seen for, well hidden within a sawale wall, or resting on or inside a lofty bamboo pole, it sends forth a stentorian call that strongly suggests the word "gecko," leisurely repeated some half dozen times and often varied with a sort of rapid stutter or a growl. It is an unhandsome, large-headed creature of anæmic aspect, though powerfully muscular, that measures from about 20 to 25 centimeters in length.

⁶⁴ Philip. Journ. Sci. 16 (1920) 213-359, 10 pls., 9 text figs.

It is somewhat variable in color, but is usually a sort of pale, lead gray spotted with brick red, the tail more or less banded with dark (Plate 8, fig. 1). The body is roughened, but scales are hardly apparent, and the large eyes dirty pale greenish yellow with a vertical black iris. The feet have well-expanded sucker disks beneath the toes which enable it to climb vertical walls and ceilings. The large jaws are lined with numerous small teeth and, although the gecko always tries to escape an enemy, it becomes aggressive when seized and will then take hold of any offending object in a bull-dog grip, which is not loosened until it feels there is a chance for escape. While typically a house lizard, the gecko is also to be found in forests, or hidden away among boulders or scrubby trees, or in some remote grass area. It does not talk much, on an average perhaps not more than two or three times daily; it thus sets a worthy example to those persons who are prone to excessive verbosity. The call of the gecko, however, has a range of several hundred feet and, when emitted from within a bamboo joint that operates as a sort of sounding box, seems specially loud. Although the vertical eye slit points to a nocturnal life, the gecko may, under the stimulus of the sight of food, become active during the daytime in its somber home under the apex of the roof (Plate 3, fig. 10). A house seems never to abound with this lizard, as it usually does with members of smaller species, which may occur in dozens therein. However, when a feast is in promise, such as a substantial flight of white ants, attracted to light, more geckoes than were thought to exist there may clamber down from the roof and partake of the repast; but it seems not at ease on the floor and is loath to descend among its smaller cousins which are boldly stuffing themselves on the fat insects. As regards prey, however, size appears to be no insurmountable object; it becomes very eager for the chase when large sphinx moths, in seeking security, or even small birds in searching for safety flutter about its ridge-pole habitat. The burly, hard-shelled coconut beetle (*Oryctes*) sometimes falls a victim to its rapacity, as testified by the loud raps, when the lizard in its endeavor to separate the wheat from the chaff strikes the insect against the bamboo to free it of its indigestible armor. The morning after shows the thorax and elytra of *Oryctes* on the floor below. Much larger objects may also be attacked, such as small rats, and the occasional fall of a snake from the ceiling may be due to its unsuccessful seizure on the part of a gecko.

The eggs (Plate 8, fig. 3), as I found them, are laid in batches; they are white, hard-shelled, and somewhat rough to the touch. Normally they are symmetrical and about 12 to 13 millimeters thick by 22 to 23 long; but, space not permitting, some may be so squeezed against their neighbors—they are evidently flexible at extrusion—as to yield to pressure and to fit an end or side into some distorting notch or angle. Such little batches of eggs were found very firmly glued inside of a bamboo node in an outhouse and also at the base of a palm petiole. In emerging, the young, banded-tail gecko makes a rough hole in the shell. Like its parent, it is then quite ready to bite when seized, and holds its jaws agape.

Gekko porosus Taylor⁶⁵ occurs in the Batan Islands, northern Philippines, where it may inhabit houses.

Smaller species of Geckonidæ that measure 10 to 12.5 centimeters long are the best known of household lizards. In British Guiana they go by the name of "wood slaves." In the Philippines, *Peropus mutilatus* is the common, fat-tailed house lizard, with *Hemidactylus frenatus* also abundant. *Cosymbotes platyurus* is likewise domiciliary, although all three, with probably other species as well, are equally at home in hollow trees, under bark, or in rocky ledges (Plate 7, fig. 4, a species from Ecuador). The tails of these lizards are very brittle and may snap off when that member is seized, to rejuvenate, often in a fantastic manner, as two or more tails in place of one. The lizards produce their calls mostly at sundown and these are varied, whether according to mood or to species I do not know; sometimes the sound suggests a tiny mocking laugh, or a noise made by knocking together two little marbles; again it may simulate a half dozen sharp kisses or, finally, serve as a good substitute, on a rather small scale, for the clicking noise one makes with the tongue and cheek when desirous of urging old Dobbin along. While insectivorous, they are in some localities also fond of sugar, and of nosing among flowers, and here I have in mind the "ohia lehua" (*Metrosideros polymorpha* Gaudichaud) of the Hawaiian Islands that they will seek indoors, probably for the nectar these blossoms secrete. In India house lizards have also been known to eat cooked rice and biscuit crumbs.⁶⁶ They do not always exhibit skill in catching their prey, often pondering and pausing over an intended

⁶⁵ Philip. Journ. Sci. 21 (1922) 187.

⁶⁶ Journ. Bombay Nat. Hist. Soc. 27: 408.

victim which may thereby escape; on the other hand, a combination of haste and inexperience that brings unpleasant results may be shown in their dealings with stinging insects, as was demonstrated one night in March, 1922, as follows: In examining by electric torch light a carton nest of a small social wasp (*Icaria cagayanensis*) that was built in the loose splicing between two posts of a veranda, I noticed one of these geckoes making some half-hearted attempts at catching a wasp or two that stood by the doorway of the nest; the wasps got away, however, evidently stinging or otherwise repelling the reptile which, thereby becoming cautious, licked its chops and carefully sniffed (it seemed) at them, and no longer essayed their capture; nay, it even backed away from an advancing wasp.

They will seize large insects, or those possessing large wings, and strike their victims from side to side against the object upon which they are resting, and this explains the knocks of a determined nature that may be heard on the walls of an evening. The geckoes quarrel considerably among themselves and thus often fall together to the floor. The pretty little white eggs have brittle shells and, as observed, are not very far from being spherical. They are deposited often loosely, in some suitable hollow, as a knot hole or crevice, or under a piece of loose bark.

Some interesting observations on *Hemidactylus flaviviridis* Rüppell, a common Indian house lizard, are published by Baini Parshad.⁶⁷

VARANIDÆ

The "monitors" are generally large to very large, elongate lizards that inhabit the Old World; *Varanus salvator* Laurente (Plate 7, fig. 5), which ranges from the East Indies to Cape York, Australia, may, rarely, attain an extreme length of 2 to 2.5 meters. It is a common species in the Philippines, where it often attracts unfavorable notice by its depredations among poultry. It is an expert climber, runner, and swimmer, and its haste when on the ground may be very noisy. While oftentimes seen in the forest, the Philippine monitor lizard, or *bayawak*, is quite at home in more-open country and there, among other things, seeks out the chicken coops and garbage dumps as sources of food. Unlike the iguana of the New World, it has

⁶⁷ Journ. Bombay Nat. Hist. Soc. 24: 834-838, 1 pl.

its rather snakelike head on a long flexible neck, and because he did not put this anatomical fact in the foreground, a member of the teaching staff at the Los Baños College was severely bitten on the hand by one of these lizards that had designs on his poultry and which he had grasped too near the shoulders. That the reptile runs many hazards during its lifetime seems to be attested by the frequently abridged condition of its tail, or by some other mutilation. Occasionally it will share man's domicile with him, provided a safe and secluded shelter can be found in it; thus, for several months a small specimen took up lodgings in the double wall in one of the old forest-station buildings and made considerable noise going to and from its quarters. In houses it has some reputation as a rat catcher.

The skink lizards (Scincidæ) are casual in houses. They are sleek, alert, and swift. Such lizards climb nimbly and like to bask in the sun. We find them on the verandas and railings, and indoors on various beams in the nipa houses, and seeking refuge within the double walls. *Sphenomorphus jagori* is a rather small brown skink with a distinct lateral stripe from behind the eyes. *Dasia smaragdinum* is greenish anteriorly above and mainly bronze on the rest of the body. Both lizards may occur in and about houses. Ants seem to be one of their common foods, but I saw one of these skinks in my room, where it was devouring the slender luminescent centipede that is common indoors; the squirming morsel gave some trouble, and much scraping and shaking of it were necessary before it entirely disappeared.

BIRDS IN HOUSES

Birds that of their own accord live in houses in the Philippines are not many; the only truly domiciliary kind observed was the common sparrow (*Passer montanus* Linnæus) some of which nested in the open end of a large bamboo pole that helped support the steeply wedge-shaped ceiling of one of the Mount Maquilung nipa houses. Of this species, McGregor says in part: ⁶⁸

The first land bird to greet the visitor to Manila will doubtless be a fringillid, *Passer montanus* (Linnæus). This species is a native of Europe that is now well established in Manila and in many of the towns along the railroads or that are reached by water transportation . . . This

⁶⁸ Philip. Journ. Sci. 16 (1920) 364.

sparrow may be seen in small flocks along wagon roads and railroads and in old fields at some distance from houses. At first sight the mountain sparrow is easily mistaken for the European house sparrow, *Passer domesticus* (Linnæus), but the two species are sufficiently distinct. The former does not seem to increase with the rapidity of its less favorably known cousin and is not so great a pest.

Birds in captivity are more numerous and, apart from domesticated canaries, we find the *puñalada*, or blood-breasted pigeon (*Phlegænas* sp.), and the *colasisi* (*Loriculus* spp.) in cages. The *colasisi* is a species of "bat parrakeet," so named from its habit of passing the night suspended, batlike, from some limb, using one or both feet for the purpose. Once I saw a huge hornbill tamely sitting on a window sill of a nipa house in Mindanao.

Among animals above the floor, one may sometimes see a monkey (*Pithecus* sp.), a rather ill-favored creature that lacks much of the brightness and manner of its tropical American cousins.

THE HOUSE BATS

Bats are mammals belonging to the order Chiroptera (Greek for hand wings), and are readily distinguished by the possession of true wings, the fore limb being greatly lengthened as a framework for the alar membrane, which also extends to the hind member and usually to the tail. The thumb is free and useful in helping the animal to crawl about; the feet have the full number of toes and are employed chiefly in suspending the body for rest. While the eyes are frequently very small and almost buried in the fur, they are efficiently supplemented by whiskers, by acute and often greatly developed ears and other facial membranes, and by the sensitive skin of the wings. The character of the teeth indicates the general nature of the food of bats, which may thus be divided into frugivorous and insectivorous species; in the former the cheek teeth have smooth crowns and are longitudinally grooved, while in the latter, with but few exceptions, the crowns of these teeth are surmounted by sharp cusps divided by transverse grooves. However, many of the so-called insectivorous bats, including the blood-sucking vampire (*Desmodus*) of the American Tropics, have a mixed diet and consume both animal and plant food, while a few others (*Megaderma*) are known to feed upon their smaller fellows and to capture small fish and even amphibians. *Megaderma lyra*, the Indian vampire bat, is said to feed habitually

on birds and mice, chewing them up in the corners of rooms or verandas.⁶⁹

Bats make no nests. The female bears one or more young of comparatively large size, which cling to her body when she is at rest and usually in flight. Thus the weight she carries is sometimes excessive. Vernon Bailey⁷⁰ points out that the weight of the several young sometimes exceeds that of their mother.

The habits of these animals are of considerable interest. Some congregate during the day in immense numbers in caves, buildings, or hollow trees; some assemble in small numbers and others are solitary. The same roosting places may be patronized for day or weeks, or they are the inheritance of generations. In countries with a cold winter bats hibernate; elsewhere they are usually active the year round. In most kinds the flight is swift and graceful, but some of the larger frugivorous species fly rather heavily and directly, and in flapping their wings produce a noise comparable to the flexing of a large piece of coarse paper. The Megachiroptera, which contains the single family Pteropodidæ, comprises the fruit eaters and includes the largest of bats, some of the "flying foxes" (*Pteropus*) of the Indo-Malayan region attaining a wing expanse of 1.5 meters or more. Such bats roost during the day in immense numbers in undisturbed regions, in mangrove swamps, bamboo thickets, or other, more or less inaccessible places, and sally forth at sunset to their feeding grounds, often many kilometers away, seriously to depredate fruit trees or injure other vegetation, and return to their "camp" before sunrise. Wild figs constitute a favorite food of frugivorous bats, and in the Philippines, and probably elsewhere as well, the natives who appreciate the flying foxes as good eating sometimes capture them as they fly about the great canopies of fig-laden trees, by tearing their wings with the long, slender and cruelly barbed flagellæ, or whip lashes, of the rattan palm (*Calamus*). *Vampyrus spectrum*, a false vampire and the largest bat of the American Tropics, is perhaps mainly a fruit-eating species, with an ugly countenance and a wing expanse of about 75 centimeters.

There are many smaller species of Megachiroptera, and in the Philippines the chief ones, found about Los Baños nipa

⁶⁹ See F. Gleadow, Journ. Bombay Nat. Hist. Soc. 17 (1922).

⁷⁰ National Geographic Magazine (September, 1925).

houses at night, measured from 30 to 50 centimeters in wing expanse and belonged to the genus *Cynopterus* (Plate 8, fig. 2) of the Pteropodinae. These animals, of which there may be several species, have rather pleasing features for, while the nostrils diverge in a bifid manner, the eyes are large and soft and the head is well formed. *Cynopterus* was observed roosting singly or in small groups; one large ill-scented fellow was taken from the hollow of a leaning tree well up in the Mount Maquiling forest, while three others were observed suspended from a dome-shape retreat formed by the underside of the crown of a small fig tree and with the darkening aid of some vines. They are voracious feeders and, while eating certain large leaves and wild fruits that I did not identify, the principal food, at least in the vicinity of the residences on Mount Maquiling, seemed to consist of the wild figs *Ficus hauili* Blanco and *Ficus nota* (Blanco) Merrill. These two species are small trees abundant along the lower edges of the forest; *F. nota* bears large masses of good-sized fruits on the stem and thicker branches, while in *F. hauili* they are smaller and solitary on the branches. Both trees are dioecious, as in the figs of commerce, the true seed figs being borne on one plant and the gall and male ones on another. While such figs are quite insipid to us, *Cynopterus* devours them in large quantities and, as far as my observations go, always selects the female or seed fruits for its repast. Several times these bats were seen to flutter over the crown of a *hauili* tree and, selecting a fig, seize and detach it with some effort and fly heavily away with it to a convenient roost. Such roost may be used over and over again and for more than one successive night, and is commonly located by the accumulation of seeds below and which the animal passes, its digestive and assimilating processes being very rapid. *Cynopterus* is not an unfamiliar bat in open houses that adjoin woods. The ceilings over verandas, or the underside of the roof of rooms are often chosen for its dining place as having the advantage perhaps of shelter from wind and rain. With a weighty fig held in wide-expanding jaws it flies up under the roof and, hooking on to the palm shingling by means of the long strong thumbs, suspends itself head down and, employing one or both hind feet and its upturned head, readily manages to eat the fruit (Plate 3, fig. 9). It eats with some deliberation and if disturbed, as by the light of an electric torch, stretches out a muscular neck and looks down upon one. The bat cannot be considered a desirable guest, since its meal is digested and passed in situ, the creature

reversing itself for the latter operation. Evidently a considerable quantity of such food is required to obtain sufficient nourishment. A few of these *Cynopterus* suspended from the roof were captured by means of a long-handled insect net. If gently treated they make docile captives and readily take food from the hand. When offered a wild fig they seize it carefully in their gaping jaws and slowly and gravely eat it. If disturbed, or when in pursuit of one another, they emit a sort of chucking noise. The flight is graceful and practically noiseless, in strong contrast to that of their huge cousins, the flying foxes (*Pteropus*).

A second and smaller species of frugivorous bat, *Carponycteris minima*?, was taken once in the old forestry-station building at Los Baños, and had evidently been attracted there to light. It measured 24.7 centimeters in well-stretched wing expanse. It is classified under the subfamily Carponycterinæ (or Macroglossinæ), the members of which, among other characters, possess elongate muzzle, well-developed canines, low molar teeth, and an exceedingly long tongue which is provided with recurved papillæ near the tip.

The Microchiroptera, or "insectivorous bats," are generally more familiar to us than are the fruit eaters, since they occur abundantly also in temperate regions, and are the bats of the belfry, of human habitations, of caves, etc. They often occur in large numbers in tropical cities in many parts of the world.

What is without doubt a familiar sight to the inhabitant of Manila who is not averse to taking a stroll during the pleasant hour of sunset, when small flocks of Chinese starlings, or "martines," *Æthiopsar cristatellus* (Linnæus), and other birds are speeding home to roost, and the hundreds, aye thousands perhaps, of bats that rise out of the Walled City, or Intramuros district, and make their way, at a height of probably from 20 to 100 meters, over the wide Calle P. Burgos to their feeding grounds. Within the Walled City are massive old Spanish buildings, excellent homes, in their upper portions, for the multitude of bats that inhabit them and the vast winged hosts flying up in flocks indicate that certain buildings or groups of them are more favored than others as roosting places. In about a half hour all are on the wing, and of the two sizes of bats that may now be readily distinguished, the smaller and far more numerous one has generally disappeared in quest of insects, while a larger, low-flying species, and not among the

first to appear, is to be seen flitting over the old moat (now the sunken gardens) that circumscribes the Walled City. At the first peep of dawn the bats seek their roosts. Similar flights of small bats may be observed elsewhere in the Philippines. *Nycticejus kuhli* (?), with its unadorned visage and a span of about 30 centimeters across the wings, has taken to living under the corrugated iron roofs of several of the buildings of the College of Agriculture at Los Baños. A visit to the dark and torrid attic of the chemistry building revealed a squeakily quarreling and sleeping population of dozens of bats, ensconced between the convex portion of the corrugations and the supports, or clinging to the large wooden beams, etc.

The Rhinolophidæ are the horseshoe and leaf-nosed bats. *Rhinolophus* (Plate 8, fig. 6), a reddish brown species about 30 centimeters in wing expanse, is not an infrequent visitant to nipa houses of Los Baños, though it probably sleeps elsewhere than in houses. Its face, with the great leaflike folds of skin that surround the nostrils in the form of a horseshoe, is not prepossessing, particularly as it is addicted to twitching the large ears and rapidly working the mouth, as if to make grimaces. It has the habit of hanging down by its feet from the bare tip of some twig or along a telephone wire, and pivoting back and forth there. The same twig may be used as a perch for some nights in succession and probably serves as a sort of dining room for the restless creature. In nipa houses, *Rhinolophus* is occasionally pendant from insulated telephone wires in unlighted rooms or verandas, but more commonly it hooks itself high up under the roof and there pivots and makes facial contortions. Sometimes it pursues night-flying insects into houses, and I recollect a screaming green *Cicada* circling my room, closely followed by this eager bat.

ILLUSTRATIONS

PLATE 1

- FIG. 1. Nipa house at Los Baños.
2. Looking up at the roof of a nipa house.

PLATE 2

- FIG. 1. *Amathusia phidippus* Linnæus; chrysalis. $\times 1$.
2. *Eumenes makilingi* sp. nov., female, type; head and pedicel, lateral aspect.
3. *Eumenes makilingi* sp. nov., male, allotype; armature and tip of antenna.
4. *Prionocerus caeruleipennis* Perty. $\times 5.7$.
5. *Prionocerus caeruleipennis* Perty. $\times 6.17$.
6. *Prionocerus caeruleipennis* Perty. $\times 6$.

PLATE 3

- FIG. 1. Caddis fly; adult at rest. $\times 0.83$.
2. *Odynerus xanthozonatus* Ashmead; young larva suspended in its cell. Enlarged.
3. *Amathusia phidippus* Linnæus awaiting sunset. $\times 1$.
4. *Erionota thrax* Linnæus, the banana leafroller; pupa, showing emergence holes of *Brachymeria* wasps. $\times 0.55$.
5. Firefly larva and its natural prey. $\times 1.5$.
6. *Eumenes makilingi* sp. nov.; mud cells. $\times 0.62$.
7. *Erionota thrax* Linnæus; retreat of large larva, or pupal chamber of the banana leafroller. Much reduced.
8. *Erionota thrax* Linnæus, retreats of young larvæ. $\times 0.28$.
9. *Cynopterus* sp., a fruit-eating bat under a nipa roof, devouring a fig. About $\times 0.3$.
10. *Gekko gecko* (Linnæus), ruler of the ridgepole. About $\times 0.1$.

PLATE 4

Hersilia spider on its web on a tree trunk.

PLATE 5

- FIG. 1. *Microcerotermes los-bañosensis* Oshima, a worker with a parasitic coleopterous larva clinging to it. $\times 13.1$.
2. *Hospitalitermes saraiensis* Oshima, the day-foraging termite; small portion of a column returning nestward in the early morning. About $\times 2.3$.

PLATE 6

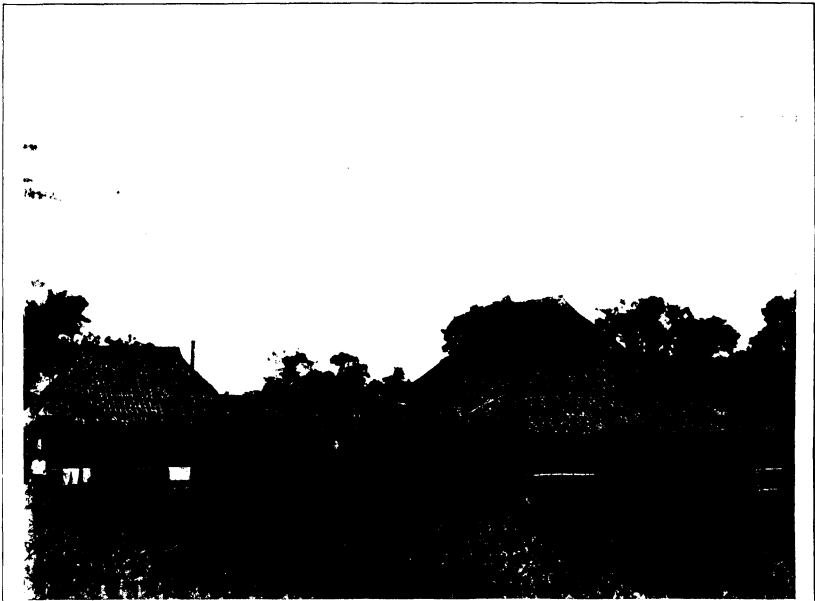
- FIG. 1. *Odynerus xanthozonatus* Ashmead; *a*, wing of female; *b*, sagitta of male armature somewhat flattened.
2. *Odynerus longitegulae* sp. nov., female, type; wing.
3. *Odynerus xanthozonatus* Ashmead; *a*, tip of antenna, male; *b*, tegula of female; *c*, clypeus of female.
4. *Odynerus longitegulae* sp. nov., type; female tegula.
5. *Rhopalum domesticum* sp. nov., female.
6. *Ancistrocerus domesticus* sp. nov., female; posterior face of propodeum.
7. *Rhopalum domesticum* sp. nov., female; venation.
8. *Crabro makilingi* sp. nov., female, paratype; *a*, clypeus; *b*, palpi.

PLATE 7

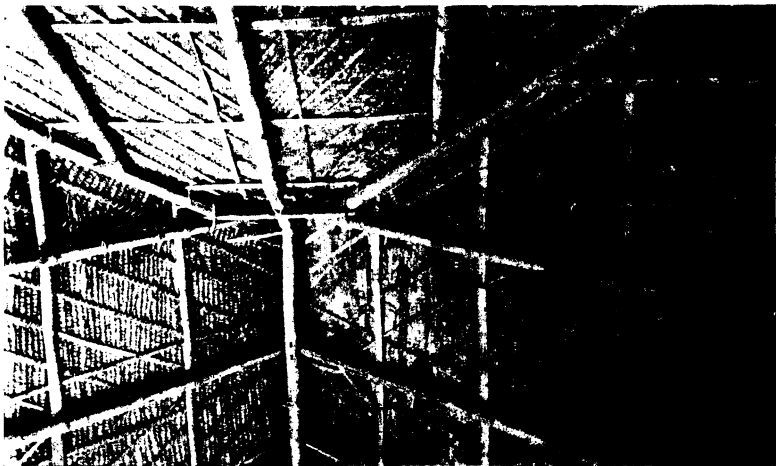
- FIG. 1. *Myrmeleon celebensis* McLachlan, an ant lion; pits under a nipa house.
2. *Nephila* spider on web.
3. *Polypedates leucomystax* Gravenhorst, banana frog; egg masses.
4. Small house lizard, from Ecuador.
5. Monitor, or *bayawak*.

PLATE 8

- FIG. 1. *Gekko*.
2. *Cynopterus*, a frugivorous bat.
3. *Gekko*, eggs and young.
4. *Polypedates leucomystax* Gravenhorst, banana frog.
5. *Heteropoda regia* Fabricius, with egg cocoon. Hawaiian specimen.
6. *Rhinolophus*, an insectivorous bat.



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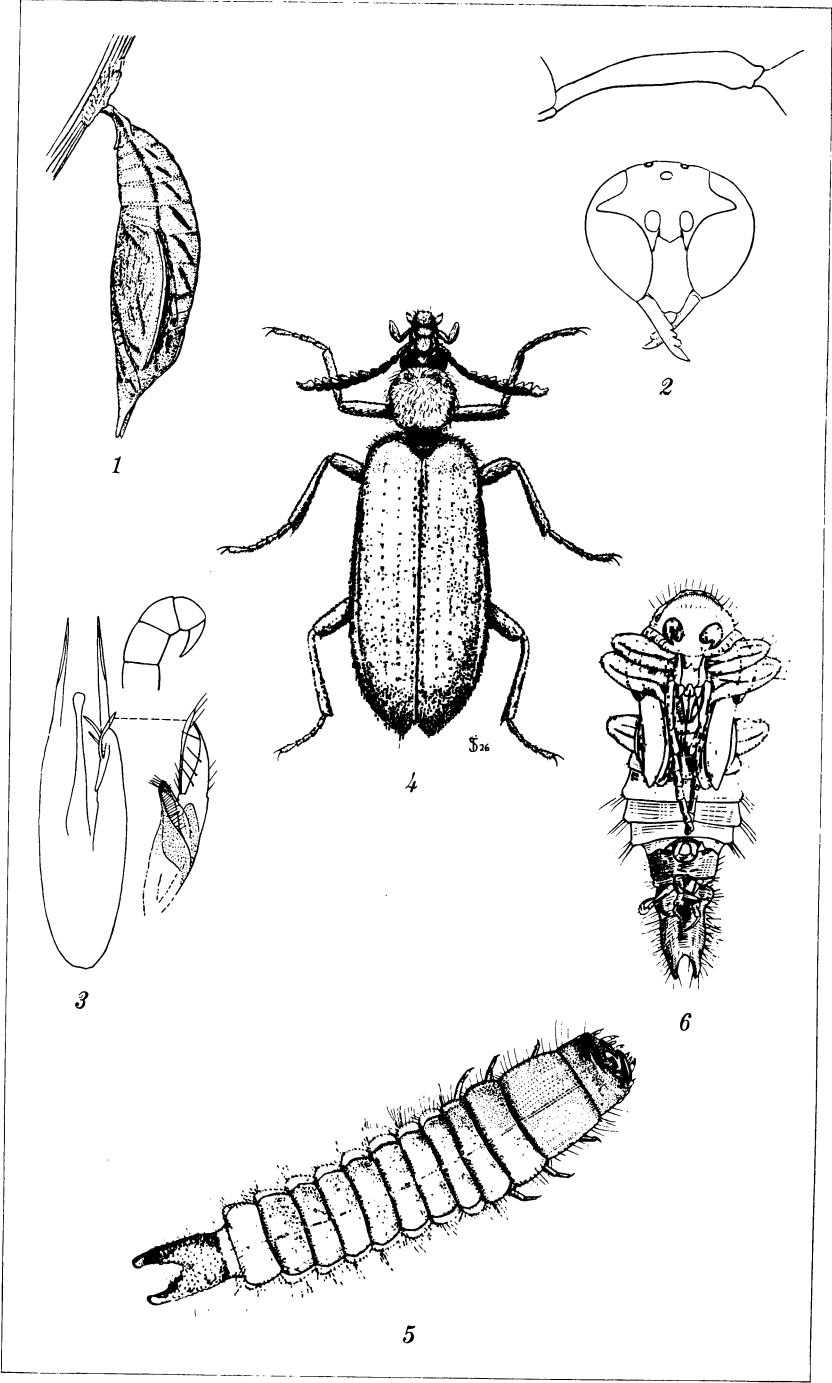


PLATE 2.

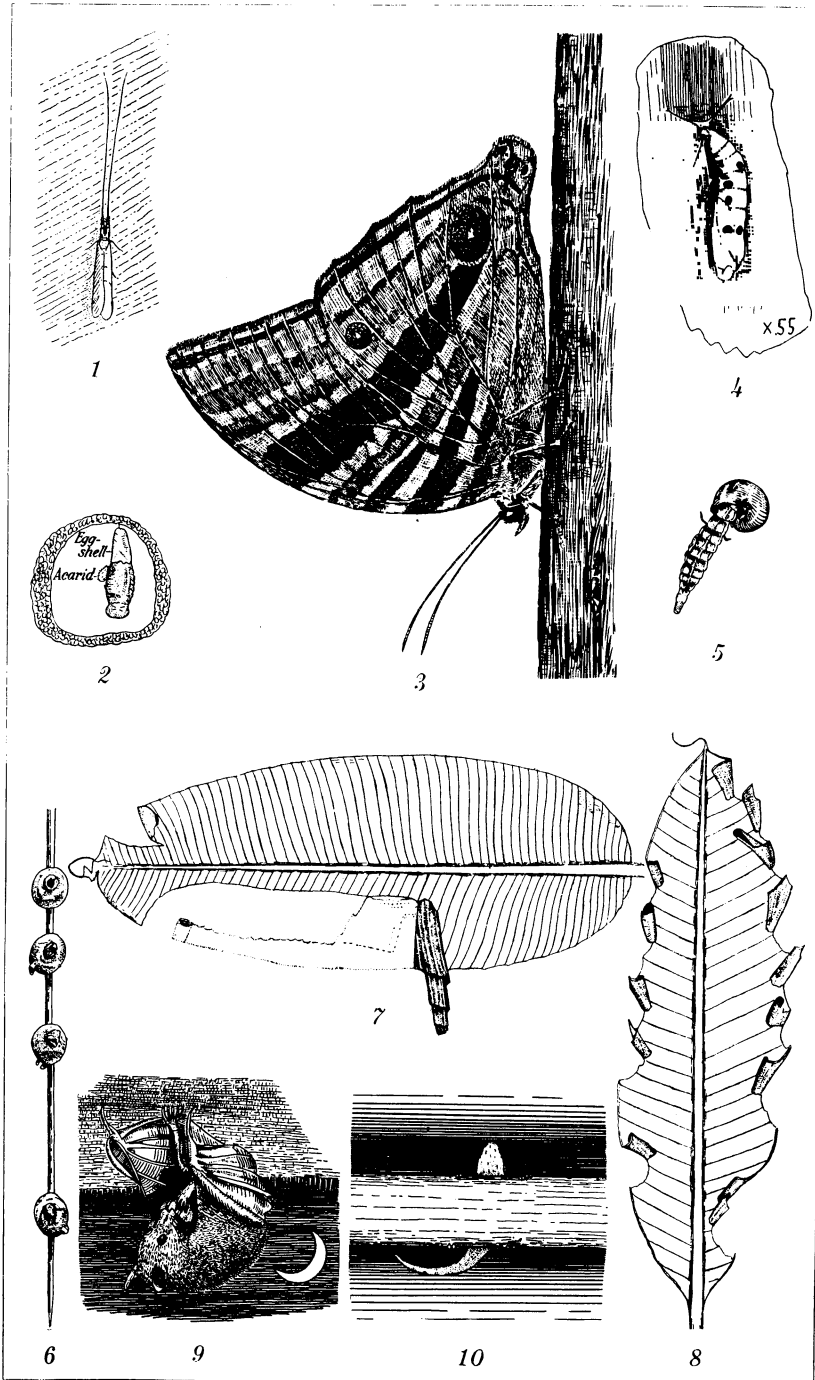


PLATE 3.

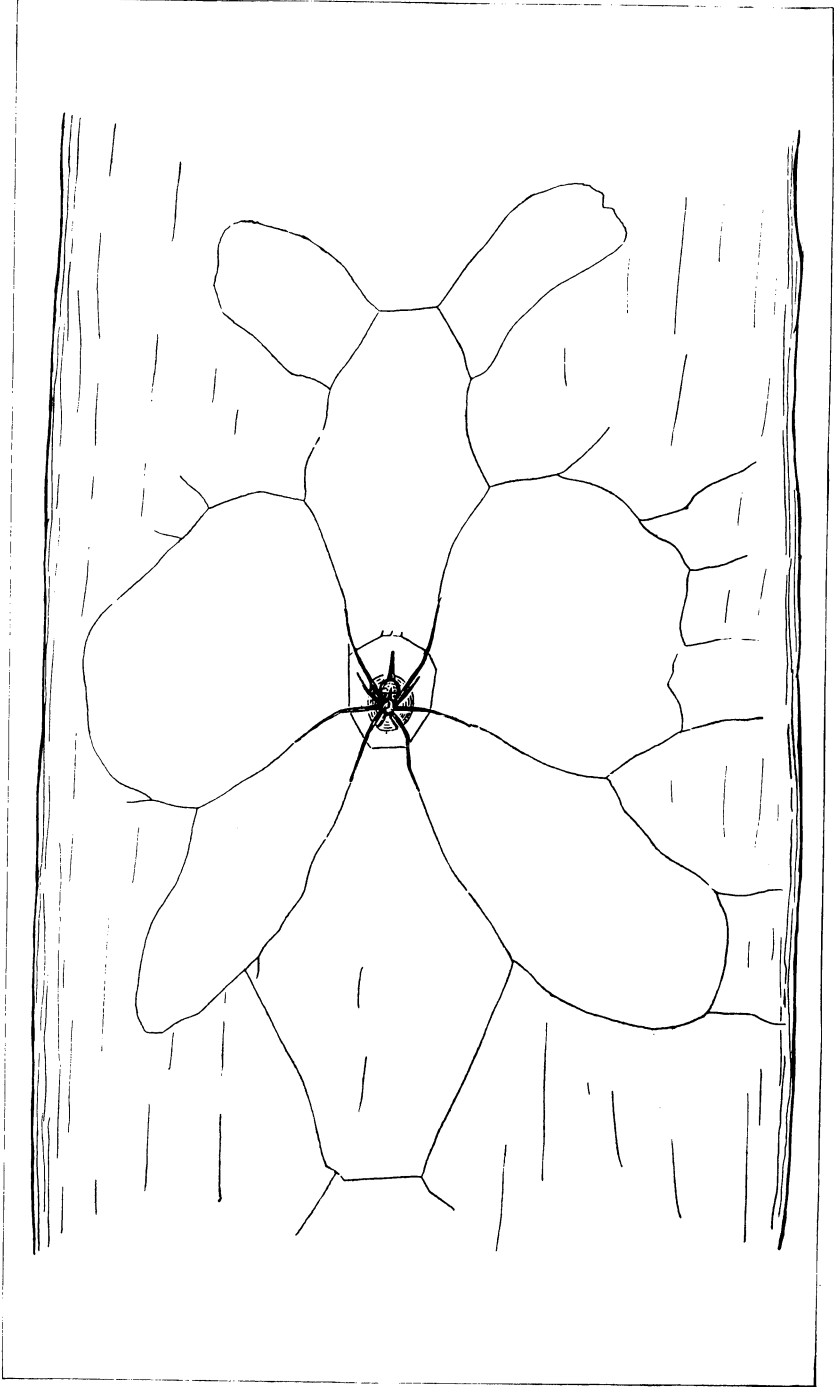
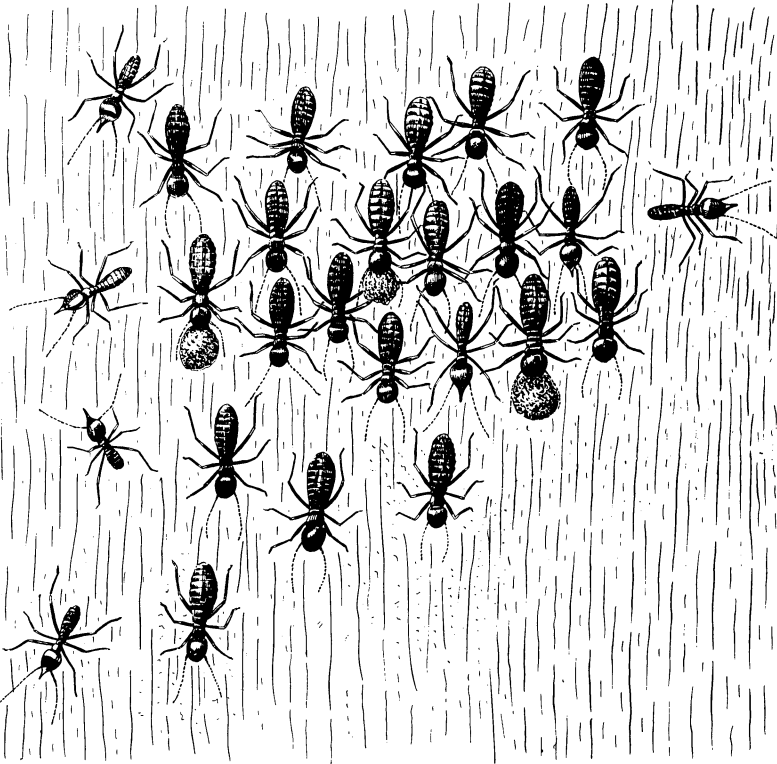
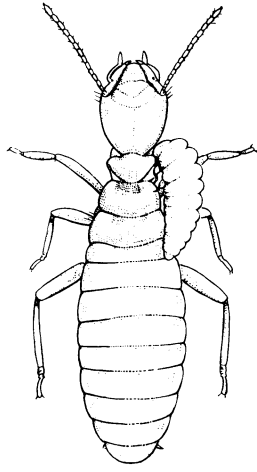


PLATE 4.



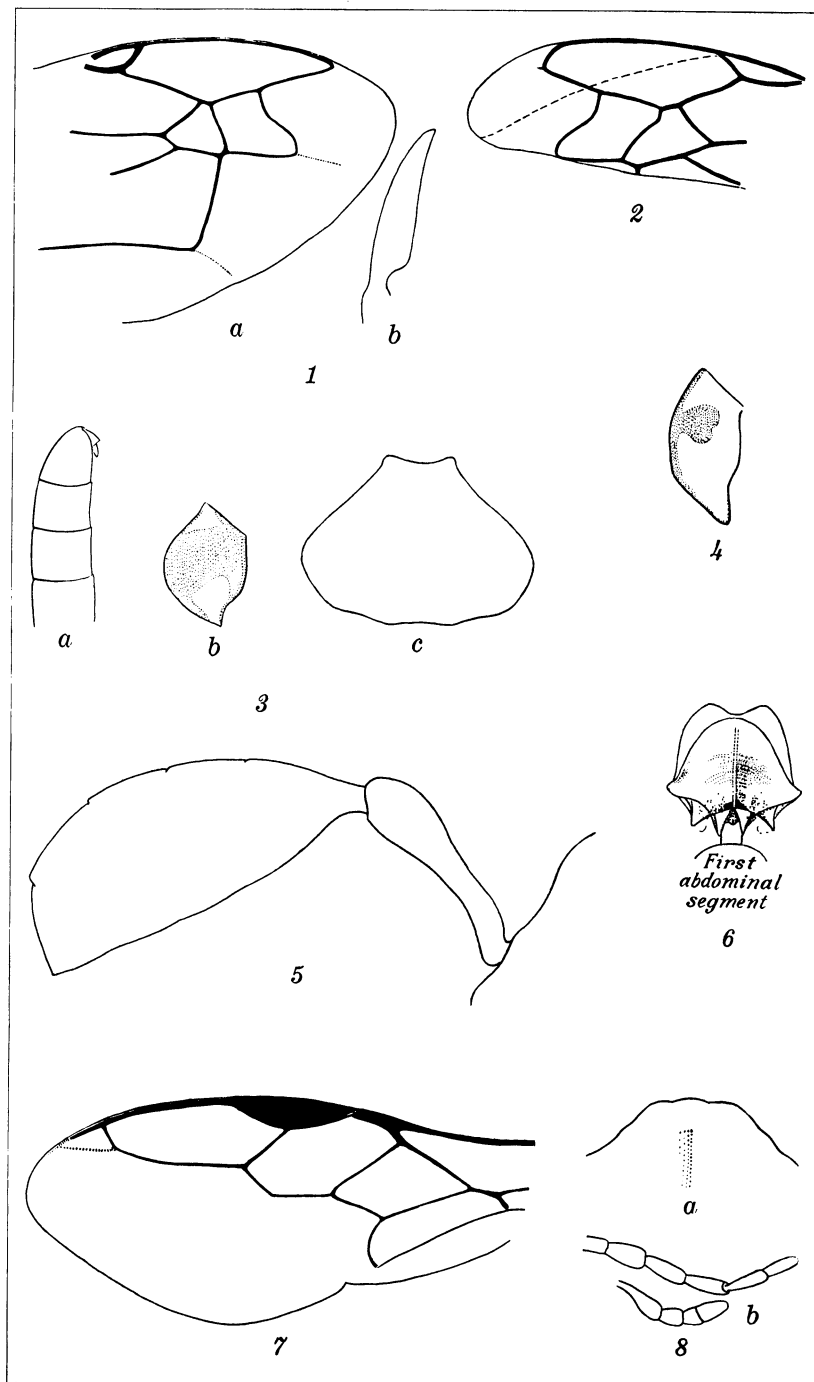
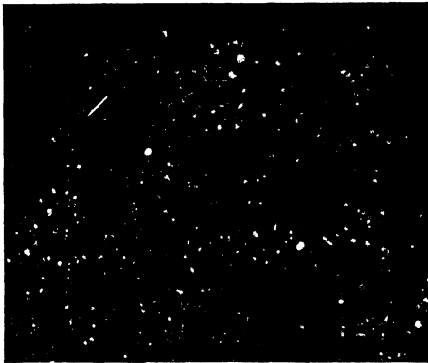
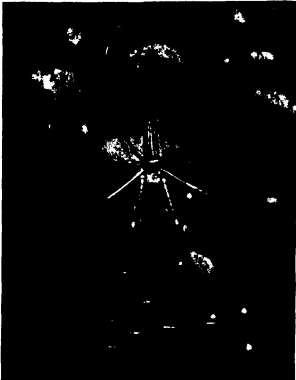


PLATE 6.



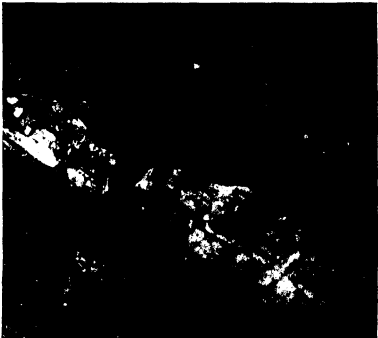
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CORRELATION OF THE TERTIARY FORMATIONS OF THE PHILIPPINES WITH THOSE OF EUROPE, ASIA, AND AMERICA

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It will be remembered that one of the results of the First Pan-Pacific Scientific Conference, held at Honolulu in 1920, was the formulation of the basis of correlation of the post-Cretaceous formations of the Pacific region. It was formulated that—¹

As the margins of the Pacific and the islands within its confines are remote from Europe, direct tracing is out of the question, but two possibilities are present. One is to correlate with Asia and work westward across it to Europe; the other is to correlate with America and through it to correlate with Europe.

The purpose of the present paper is to present a tentative correlation of the older Tertiary formations of the Philippines with standards already established in Europe, Asia, and America—not so much to establish definitely the assignment of these horizons to subdivisions of the Tertiary as to call attention to the fact that the previous assignment of the Batan, the Binañgonan, and the Vigo formations to Miocene is not supported by palæontological evidence. In this attempt at tenta-

¹ Vaughan, T. W., The basis of the correlation of post-Cretaceous formations of the Pacific region, Proc. First Pan-Pacific Scientific Conference, Honolulu (1921) 867.

tive correlation several things are borne in mind; namely, ² (1) "in similar Neogene sediments of Europe and the Indies the deposits in the latter region must contain a higher percentage of living species than the former;" (2) tracing from Europe to southeastern Asia is possible only for early Eocene; and (3) the presence of similar organisms in post-Eocene formations of the East Indies and Europe is due to migration across Central America from the Atlantic to the Pacific, or vice-versa, during middle and later Eocene time, middle and later Oligocene time, and oldest Miocene time.

In the Philippines the lowest horizon of the Tertiary, the Eocene, is recognized, although it must be said that beds of Eocene age are known only at very few localities. At least a portion of the Philippines was land mass during Eocene time, but the fossil terrestrial fauna and flora are at present very imperfectly known.

The best known and the most widespread of the older Tertiary formations of the Philippines is a series consisting of shales and grit with coal, shales and sandstones with oil seeps, and limestones with large-sized *Lepidocyclina*. Three quite distinct formations make up this series; namely, the Batan, the Binañgonan, and the Vigo. The Batan formation, first named by Smith ³ in 1913, consists of alternating gray shales, grits, sandstone, and coal seams, and has a thickness in some places of several hundred meters. The Binañgonan formation is yellow to white or bluish gray limestone, massive or heavily bedded, containing large-sized Foraminifera, the forms measuring 2 centimeters or more in diameter. This formation was also first named by Smith ⁴ although in a later publication ⁵ he changed the name to Cebu limestone. The Vigo formation consists of alternating beds of bluish gray, gray, or black shales and yellow and brown sandstones, sometimes massive or imperfectly bedded. According to Dickerson, ⁶ the limestone containing the large-sized *Lepidocyclina* is equivalent to the shales and sandstones of the Vigo formation and "the limestones, shales, sand-

² Martin, K., The age of the Tertiary sediments of Java, Proc. First Pan-Pacific Scientific Conference, Honolulu (1921) 763.

³ Philip. Journ. Sci. § A 8 (1913) 242.

⁴ Loc. cit.

⁵ Geology and Mineral Resources of the Philippine Islands, Bur. Sci. Pub. 19 (1924) 78.

⁶ Philip. Journ. Sci. 20 (1922) 209.

stones, and coal are different depositional facies within the same group."

The stratigraphy of the coal-bearing formation has been the subject of investigation by a number of workers. Becker and Abella, among others, regarded it as Eocene, while Smith and Dickerson assigned it to the Miocene. On the basis of Foraminifera, Douvillé referred the lignitic horizon to the Oligocene. In places, notably in Cebu, the Vigo shales lie above the coal measures. In other places the Binañgonan limestone lies in patches over the coal measures.

The foraminiferal fauna of the Binañgonan limestone has also been the subject of a number of investigations. The findings of Douvillé⁷ and of Yabe⁸ give the genus *Lepidocyclina* as the most characteristic fossil. Douvillé correlates the middle limestone with large *Lepidocyclina* with the Aquitanian, and the lignitic horizon and lower limestone with the Stampian, which represents Oligocene. Douvillé's determinations were based on a sample of bluish gray limestone (upon which the foraminifers stood out in black) from Batan Island, one of the Philippine coal fields. He found it to contain *Nummulites subniasi* and a curious *Lepidocyclina* belonging in the section of *Nephrolepidina*, *L. smithi*. The coexistence of *Nummulites* and *Lepidocyclina* is regarded by him as characteristic of the Stampian, Oligocene. This limestone is a part of the lignitic horizon and is found intercalated between beds of lignite. The following table summarizes the conclusions of Douvillé:

Philippines.		Borneo.
II.	Upper limestones with small lepidocyclinas.....	<i>Lepidocyclina verbeeki</i>
		<i>Miogypsina</i>
		<i>Cyclocypeus communis</i>
	Middle limestone.....	<i>Cyclocypeus communis</i>
		<i>Operculina complanata</i>
	Lower limestones with large lepidocyclinas.....	<i>Lepidocyclina insulaenatalis</i>
I.		<i>Lepidocyclina richthofeni</i>
		<i>Lepidocyclina formosa</i>
	Lignitic horizon and lower limestones with nummulites.....	<i>Nummulites subniasi</i>
		<i>Amphistegina niasi</i>
		<i>Lepidocyclina smithi</i>

⁷ Les foraminifères dans le Tertiaire des Philippines, Philip. Journ. Sci. § D 6 (1911) 53-80, 4 pls.

⁸ Notes on a *Lepidocyclina* limestone from Abu, Science Reports, Tohoku Imp. Univ. 5 (1919).

The work of Cushman⁹ in the American Caribbean region on fossil Foraminifera gives the range of the genus *Lepidocyclus* as upper Eocene to Oligocene. Vrendenburg's¹⁰ studies on the distribution of the genus *Lepidocyclus* in the nummulitic series of India showed that *Lepidocyclus* occurs from the very base of the Oligocene as far as the series are developed. Yabe,¹¹ analyzing the results of Rutten's studies of foraminiferal rocks from southern and eastern parts of Borneo, says in part:

Thus the oldest Miocene and Oligocene deposits, according to Rutten, are characterized by *Lepidocyclus* of larger and smaller sizes, while the smaller ones alone are found together with *Miogyopsis* in all parts of Miocene deposits except the lowest division.

It is thus seen that, while in the American Caribbean region *Lepidocyclus* is characteristic of upper Eocene and Oligocene, in India and in the islands of the East Indies it starts from the base of the Oligocene and ranges through the Miocene. The presence of *Lepidocyclus* in foraminiferal rocks in the Philippines can then be regarded as indicating at least Oligocene age.

Mr. Dale D. Sparks, at present palæontologist for Cia. Em-mex de Petroleo y Gas, South America, while working on orbitoid Foraminifera at Leland Stanford Junior University, California, examined sections of Philippine *Lepidocyclus* limestone from Montalban Gorge, near Manila, Rizal Province, and identified, besides the species recognized by Douvillé and by Yabe, *Lepidocyclus canellei* Lemoine and R. Douvillé. This species is identified by comparison with the figures and descriptions of Cushman.¹²

Lepidocyclus canellei Lemoine and R. Douvillé has been collected from the Antigua formation (Oligocene) of the Island of Antigua in the West Indies, from the Culebra formation (Oligocene) of the Canal Zone (both type localities of subdivisions of the Tertiary system in the West Indies and Central America), and from the Oligocene of Trinidad.

The most characteristic molluscan fossil of the coal measures is *Vicarya callosa* Jenkins. This species has never been found in beds overlying the series, and is moderately common through-

⁹ The American species of *Orthophragmina* and *Lepidocyclus*, Prof. Paper 125-D, U. S. Geol. Surv. (1920).

¹⁰ Rec. Geol. Surv. of India 35¹ (1907) 63.

¹¹ Notes on a *Carpenteria* limestone from British North Borneo, Science Reports, Tohoku Imp. Univ. II 5² (1919) 1.

¹² The American species of *Orthophragmina* and *Lepidocyclus*, Prof. Paper 125-D, U. S. Geol. Surv. (1920).

out the Philippines. It was first reported by Martin,¹³ and has been considered by him and others as a good guide to the tropical Miocene. It will be noted that there are only two species of *Vicarya*; one is *V. verneuili* d'Arch. and the other is *V. callosa* Jenkins. Martin¹⁴ noted that it will be difficult to separate the two species as long as *V. verneuili* is represented by such poor material, and he expresses the opinion that probably the two forms belong to one very variable species. Regarding the range of the genus, Martin¹⁵ has the following to say:

For *V. callosa* Jenk. has hitherto been found only in the upper Miocene of Java, and *V. verneuili* d'Arch. occurs only in the Gaj series of western India, which also belongs to the Miocene.

In this connection it is interesting to note the conclusions of Vrendenburg¹⁶ in his analysis of the Singu fauna, in which he expresses the opinion that the Singu beds are Oligocene. *Vicarya verneuili* occurs in bed P at the upper limit of the older subdivision, which is characterized by the typically Oligocene fossil *Turritella magnasperula*.

Another molluscan criterion for referring the lignitic horizon to Oligocene is provided by the finding by Smith¹⁷ in the lower limestone on Batan Island of *Ampullinopsis*. Dr. W. H. Dall, of the Smithsonian Institution, is authority for the statement that the presence of *Ampullinopsis* is an indication of Oligocene age. Regarding the Batan beds, the following statement by Reinhott¹⁸ is of particular interest:

The sedimentary series belong unquestionably to the Tertiary period. Professor Mayer of Zurich and Doctor Dall of our Smithsonian Institute agree, from the examination of fossils collected and personally submitted by me, that the upper limestone should be referred to the Oligocene epoch.

It has been claimed by Dickerson¹⁹ that 75 per cent of the specifically determined forms from the Vigo are referable to living species. It is difficult to subscribe to this assertion, because Dickerson presented only a list of species the determination of which cannot be checked and, judging from the few

¹³ Sammlungen des geologischen Reichsmuseums, Leiden 5 (1896) 53-69.

¹⁴ Sammlungen des geologischen Reichsmuseums Leiden, Heft III Neue Folge, 2 (April, 1917).

¹⁵ Loc. cit.

¹⁶ Rec. Geol. Surv. of India 53⁴ (1921).

¹⁷ Contributions to the stratigraphy and fossil invertebrate fauna of the Philippine Islands, Philip. Journ. Sci. § A 8 (1913) 240.

¹⁸ Eng. Mag. (1906) 30, 510.

¹⁹ Review of Philippine paleontology, Philip. Journ. Sci. 20 (1922) 203.

figures he presented, several of his determinations are not precise. It is admitted that a large percentage of the fossils present in the Vigo formation are still living in Philippine waters, but it is seriously questioned whether the percentage is as high as 75 per cent.

There is wide disagreement between Doctor Dickerson and myself as regards systematic classification. Doctor Dickerson's specimens are not in the Bureau of Science palæontological collection; they were collected while he was chief geologist for the Richmond Petroleum Company and were taken away upon completion of its work in the Philippines. I am hoping that some colleague will have a chance to reexamine the material in order that the percentage of species common to the beds may be compared with some accuracy. My identifications of his species were made by examination of the figures he presented. The plates discussed below, which accompany his paper just cited¹⁹ will serve to illustrate wherein we differ:

Plate 2, fig. 22, *Epitonium* sp. This is not an *Epitonium*, as it has no ribs and the aperture is not round. It is probably a *Pyramidella*.

Plate 3, figs. 14a, 14b, *Nassa crenulata* Bruguiere. *Nassa crenulata* Bruguiere is the same as *Nassa arcularia* Linné and has a flaring lip. The shell figured is probably *Nassa crenata* Hinds or its variety *margaritifera* Dunker.

Plate 4, fig. 9, *Oliva* cf. *utriculus* Gmelin. *Oliva utriculus* Gmelin is the same as *Oliva gibbosa* Born and has a callous columella. The shell figured looks more like *Oliva acuminata* Lamarck or *Oliva nebulosa* Lamarck.

Plate 7, fig. 4, *Spisula* sp. This is not a *Spisula*, as this genus has concentric ribbing only, never cross-hatching or basket work, as shown in the figure.

Plate 12, figs. 6a, 6b, *Flabellum* cf. *australe* Moseley. This is very different from *Flabellum australe*, which is a large, dense, heavy shell, with no pronounced costal markings.

Plate 12, fig. 7, *Leptoria* sp. This is probably a species of *Maeandra*. *Leptoria* has long valleys and a lamellar columella.

Plate 13, figs. 3a, 3b, *Clypeaster* sp. This is not a *Clypeaster*; it is a *Peronella*.

It would seem there is sufficient ground for questioning the correctness of Dickerson's determinations and, until more reliable work has been done on the determination of the fossil species, the percentage of the living species in the Vigo beds cannot be estimated.

In addition to the foregoing palæontologic evidence, the following notes by Dr. Bailey Willis, of Leland Stanford Junior University, who spent about two months in the Philippines and

visited Luzon, Cebu, and Mindanao, are of great interest, as they represent the physiographic side of the matter. Doctor Willis says:

Judging by the physiographic maturity of the plateau of northern Luzon and the Diuata range of Mindanao, the uplifts have been exposed to subaerial erosion since early Miocene time. If this be so the limestone [*Binañgonan*]²⁰ involved in the structure of these masses must be pre-Miocene and probably Oligocene.

The correlation of the later Miocene and younger deposits must in a large measure be made by interpolation, based upon the degree of faunal similarity or dissimilarity between the Oligocene faunas on the one hand and the Pleistocene and Recent marine faunas on the other. Thorough familiarity with the Recent fauna is thus seen to be absolutely necessary, and students of Philippine stratigraphy, palæontology, and geologic history must begin with the study of the existing marine fauna in and about the Archipelago. In this connection attention is directed to Cushman's Foraminifera of the Philippine and Adjacent Seas, Bartsch's studies on Philippine land Mollusca, and two recent publications of mine, Recent Madreporaria of the Philippine Islands and Summary of Philippine Marine and Fresh-water Mollusks, as aids to Philippine palæontologic research.

In conclusion, while I am of the opinion that the Batan, the Binañgonan, and the Vigo formations should be referred to the Oligocene age, it should be stated that Philippine stratigraphy must be worked out in detail first and assignment to established standards made later. It is desired to call attention to the fact that reference of Philippine formations to divisions of the Tertiary are based on fragmentary evidence and must not be taken too seriously. While it is convenient to use the international names of the subdivisions of the Tertiary, the use of Philippine formational names to indicate horizons is much to be preferred. The definite assignment of the Vigo to the Miocene is premature and, as has been shown, not in accordance with palæontologic and physiographic evidence. The use, therefore, of Vigo-Miocene should be discontinued. When the stratigraphy of the Philippine Islands has been worked out in detail and the sequence of the different strata is known with more or less definiteness, then assignment of the different formations to subdivisions of the Tertiary will be in order.

²⁰ Italics are mine.—L. A. F.

NOTE ON LOCAL TERMINOLOGY OF CERTAIN MANIFESTATIONS OF YAWS

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Considerable misunderstanding and confusion have arisen from the use in the literature of local popular names in the designation of the clinical manifestations of yaws. The polyglot nature of the literature concerning yaws has further contributed to this confusion. Unfortunately, the practice of using local colloquial terms becomes almost indispensable after long residence in any particular tropical country. Throughout what may be styled the Latin Tropics, the popular Spanish nomenclature of yaws manifestations is generally understood, whatever the names of the same affliction may be in the native dialects. This, however, appears not always to be the case with frambæsiologists who have worked among other than Spanish-speaking people, owing to the similarity of some Spanish words to Latin words and to the fact that, having preserved a great similarity to Latin, these Spanish words have acquired a new shade of meaning. As an instance of such misunderstanding arising from the use of local names we may cite the review of our paper in a recent publication.¹ There the reviewer takes exception to our statement concerning the word "clavos."

For the information of the reader who may not be familiar with the popular medical terminology used in the Latin Tropics, the following explanation is presented.

In the minds of patients and other laymen the word *clavos* (plural of *clavo*) connotes any form of yaws, of long duration, that is located on the palms of the hands or, more frequently, on the soles of the feet and inconveniences the patient in walking or in performing manual work. At least four forms of yaws manifestations may be distinguished. Without diagnostic differentiation, all of them are popularly called "clavos."

¹ Trop. Diseases Bull. 24 (1927) 300, 301.

First, a persistent primary lesion, located most frequently around the ankles, that has developed an ulcerative form and gradually has extended to the dorsoplantar margin of the foot.

Second, a metastatic yaw located on or about the dorsoplantar margin or the sole of the foot.

Third, a typical, persistent late lesion termed "keratodermia" by Castellani and by others, as Gutierrez included it under the term keratosis.

Fourth, psoriasis palmaris or plantaris frambœsica.

The palm lesions described and illustrated in our paper² were metastatic, inflammatory, exudative efflorescences. They started as distinct, slightly elevated, reddish macules with subsequent central circular exfoliation of the white, thin epidermis. This exfoliation advanced toward the periphery of the lesion much faster than the spreading of the elevated macule progressed. The defects thus produced appeared reddish and fairly dry. There was no crust formation or oozing. These were early acute, metastatic efflorescences that occurred simultaneously with the cropping out of typical yaws on the other parts of the body. On the palms they occurred in successive crops, and new ones developed while the old ones were fading away. Sometimes they became confluent, producing maplike exfoliated lesions. At other times they would disappear before the exfoliation set in. No keratosis, either of the primary efflorescence or of the skin surrounding the lesions, was observed at first.

Contrary to the belief expressed by H. S. Stanus, we distinguish the lesion on the palms as described in our publication³ from the commoner lesion called "keratodermia" by Castellani and Chalmers. We consider the lesion we described to be an early, metastatic, evanescent frambœside that appears, first, as a flat, elevated, reddish macule, subsequently undergoing exfoliation. In the lesion termed keratodermia by Castellani and Chalmers the inflammatory reaction is pushed into the background, and the lesion, from the start, appears as a slow, diffuse, and extensive keratosis of the sole. The last-named lesion is a late manifestation of yaws and is persistent.

Any of these four lesions having reached the thick skin of the margin or the pads of the sole will produce its further and painful thickening. They are then promiscuously called "clavos." The

² Schöbl, Otto, A. W. Sellards, and G. R. Lacy, Some protean manifestations of the skin lesions of yaws, *Philip. Journ. Sci.* 30 (1926) 475-481.

³ Loc. cit.

Spanish word *clavos* means iron spikes or nails (not finger nails or toe nails). It is not identical with the dermatological term *clavus*. The Spanish name for corn (*clavus*) is *ojo de gallo* (chicken-eye); that of callus is *callos*. Consequently, the term *clavos* does not exclusively mean such extensive and diffuse thickening of the epidermis of the soles or palms as one finds in *keratoderma*.

Aside from the last-mentioned condition (*keratoderma plantare*) we include under the name *clavos* the metastatic yaw located on the sole of the foot or palm of the hand.

The early and evanescent metastatic frambœside on the palm of the hand, as described in our paper,⁴ and the keratosis of the skin surrounding these lesions is a combination of the two processes. In this stage the lesion is indistinguishable from the so-called *psoriasis palmaris syphilitica*, otherwise *syphilderma manus*. Any form of yaws manifestation located on the sole of the foot or on the palm of the hand will sooner or later show more or less pronounced keratosis, but the three forms of generalized yaws above mentioned must be considered as morphologically distinct.

The grounds on which this differentiation is based are the following:

1. MORPHOLOGIC DIFFERENCES OF THE PRIMARY EFFLORESCENCES

One form starts as a macule, which changes into a flat papule with subsequent exfoliation of the epidermis within the area covered by the lesion. Some of these frambœsides disappear before exfoliation sets in, while others are superseded by a diffuse hyperkeratosis of the skin surrounding the frambœsides.

Another type of lesion commences as a metastatic yaw modified by the thickness of the skin of the sole or the palm, as the case may be. Subsequently, the keratotic process surrounding the yaw extends farther over the hitherto unaffected skin.

The third type of lesion is a diffuse hyperkeratosis from the very beginning. Exfoliation of the superficial layers of the excessively thickened epidermis produces either large, maplike, superficial defects with cribrated basis, or the effect known in the literature as "moth-eaten feet." In other instances there develops a lesion described in the literature as *keratoderma sulcatum*.

⁴ Loc. cit.

2. DIFFERENCES IN PATHOGENY

The other reason why the three manifestations of generalized yaws on the palms and soles should be considered as distinct forms is their different pathogeny. The first-mentioned two forms are metastatic lesions; one commencing as a metastatic yaw, the other as an early metastatic frambœside. This pathogeny is suggested by their coincidence with metastatic yaws manifestation on other parts of the body. The third form occurs as often in cases that never have exhibited a so-called "secondary stage" as it does in those that have exhibited that stage.

The correctness of this conclusion, drawn from clinical observation, has been fully confirmed by experimental evidence, which will be published in an early number of the Philippine Journal of Science. While the macular exfoliative process described by us was observed exclusively in experimental animals showing generalized yaws, the third form (keratoderma plantare) was observed to be particularly pronounced in those animals that showed late so-called tertiary lesions (gangosa) without "secondaries."

Taking up the remark of the reviewer⁵ as to one of the lesions described by Gutierrez and quoted by us as likely to be identical with our experimental lesion that we designated keratoid frambœside, we disagree with the opinion expressed by him that one of the lesions is "melung." The name "melung" is a local name used by a tribe of Negroes in Africa. The spelling of this word was coined by Ziemann⁶ in such a way as to enable a German not an English-speaking person to approximate, phonetically, the pronunciation of the native word. In order to show the grounds on which we claim that the lesion described by us and that previously described by Gutierrez are identical and quite different from "melung" we must refer to the original article of Ziemann for the definition of the lesion. Translating freely, we find it described as a slowly progressing depigmentation of the skin and the hair. It is symmetric, appearing in blotches which become at times confluent, *but always intersected by normal pigmented skin*. The *thickness of the epidermis*

⁵ Trop. Diseases Bull. 24 (1927) 300, 301.

⁶ Ueber "Melung" (Beta bei den Duala-Negern), eine eigenartige Hautkrankheit der Neger in West-Africa, von Dr. Hans Ziemann, Marineoberstabsarzt und Regierungsarzt, Archiv für Derm. und Syph. 74 (1905) 163.

is reduced. The surface is very smooth and the margins of the depigmented lesions are sharp and show no sign of inflammation. The entire depigmented lesion is not raised above the level of the surrounding normal skin. It is called by Ziemann "partial vitiligo" or "leucoderma."

It is distributed over the palms and dorsa of the hands and on the soles and dorsa of the feet, but never extends above the distal third of the leg or forearm.

The lesion experimentally produced by us took the form of a crop of macular circinated depigmented lesions that included the hair. It was raised above the level of the surrounding skin and consisted of elevated papules. The lesion, therefore, was rough on palpation, its individual papules resembling those of *keratosis pilaris*. The margin showed a slightly inflamed base. Desquamation was only slightly developed. The thickened epidermis was easily scraped off and the base did not bleed. The lesions were located on the trunk of the body, the hands and feet being free from them.

The lesions described and illustrated by Gutierrez⁷ are, as is clearly evident from his photograph, raised and depigmented. They are seen to consist in a "follicular heaping" and are located on the back and on the forearms and show "furfuraceous desquamation." The hands and feet are free from them.

It is evident from this brief comparative description that the only thing in common between the lesions described by us and those previously described by Gutierrez on the one hand, and those described by Ziemann as "melung" on the other, is the depigmentation. The lesions similar to the "melung" of Ziemann are not absent in the Philippines. An illustration of a case is given in Gutierrez's publication,⁸ where the vitiligo is combined with *keratoderma plantare*. It is possible that the "melung" described by Ziemann is nothing but an aftermath of yaws, in as much as it is known that both the hyperpigmentation, but more particularly the depigmentation, of the skin following yaws is very persistent. However, it is quite as possible that at least some of the so-called "melung" cases are lesions of another etiology.

⁷ Yaws: Its manifestations and treatment by neosalvarsan, Arch. Derm. and Syphilol. 6 (1922) 265-287, fig. 13.

⁸ Keratosis palmaris et plantaris due to Framboesia, Arch. Derm. and Syphilol. 8 (1923) 382-392, fig. 5.

The purpose of the dermatologic descriptions and illustrations in our paper ⁹ was not to present new or hitherto unknown skin manifestations of yaws. Our sole aim was to give a description of the lesions, not only that those familiar with yaws could recognize them, but also that dermatologists unacquainted with tropical medicine might recognize these lesions, because of their versatility in dermatology. Consequently, in the absence of uniform dermatologic nomenclature, these lesions were likened by us to skin diseases known the world over, including the Tropics. Thus the names lichenoid (lichen planus), keratoid (keratosis pilaris), frambœsiderma manus (syphiloderma manus) were applied.

The main reason for publishing our paper is the fact that "All of the three atypical lesions herein ¹⁰ described were observed in experimental cases whereby their etiology was definitely determined."

⁹ Schöbl, Otto, A. W. Sellards, and G. R. Lacy, Some protean manifestations of the skin lesions of yaws, *Philip. Journ. Sci.* **30** (1926) 475-481.

¹⁰ Loc. cit.

NOTE ON BACTERIOLOGICAL DIAGNOSIS OF BACILLARY DYSENTERY

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SEVEN TEXT FIGURES

In a country like the Philippines, where bacillary dysentery is endemic and occurs throughout the year with more or less regularity during a certain season of the year, the clinical diagnosis in the majority of cases offers little difficulty to the practitioner. The sudden onset, rise of temperature, abdominal pain, and occurrence of several cases within a few days in a community leads the physician, provided he has excluded cholera, to the diagnosis of bacillary dysentery. Although the severity of outbreaks and the mortality vary from time to time, bacillary dysentery usually scores heavily among children. It is a generally accepted tradition in dysentery-stricken countries that cases among them caused by the Shiga-Kruse type of *Bacillus dysenteriae* are more severe and mortality is higher than in those caused by mannite fermenters. This should not, however, be construed to mean that cases caused by mannite fermenters do not need immediate and prompt therapy. A physician should not let himself be misled by the report of the laboratory that the case is a light one if not caused by the Shiga-Kruse type of *B. dysenteriae*. It is strongly advised, and practice bears this out, that the physician do not await the bacteriological diagnosis but commence serum therapy immediately. An experience in the Philippines of more than ten years in serum therapy of dysenteric cases has shown that the mortality in bacillary dysentery, in adults and children alike, can be reduced to the minimum by prompt application of serum in sufficient quantity but principally by administering the serum as early as possible. An alert physician will insist on examining the stool himself in a case of intestinal disorder and, with little experience, he will be able to discover by the naked eye strips of mucus or strips of mucus and blood in the still faecal stool

that will lead him, in consideration of other clinical symptoms, to diagnose the case as bacillary dysentery and to take immediate steps by injecting antidysenteric serum and requesting laboratory confirmation of his clinical diagnosis of bacillary dysentery. The findings made by the naked eye of mucus and blood will be further confirmed by microscopic examination. The helpfulness of this method has been repeatedly pointed out.(2) In the great majority of acute cases of dysentery it will be possible to confirm bacteriologically the clinical and microscopic diagnosis of dysentery.

Naturally, the collection of samples and the selection of the portion of the stool to be used for laboratory examination are of utmost importance. This has been demonstrated by Saisawa and Tanabe(7) in their work on healthy dysentery carriers, and also in the work of Vazquez-Colet(9) on dysentery carriers among food handlers in the Philippines. When it is once realized that a case of chronic dysentery exists and is causing intestinal disorders and that the pathologic changes are localized in the end of the large intestine, of either a mucous chronic inflammatory character or an ulcerative chronic type, it will at once become evident that the distribution of the dysentery bacilli throughout the specimen of stool is not so uniform as in cholera, or even in typhoid, and the importance of selecting from the specimen a special portion macroscopically suspicious as the dysenteric inflammatory product will be recognized. Owing to the lack in bacteriological technic of enrichment medium and of standard procedure for isolating *B. dysenterix*, one of us suggested years ago(6) the use of Teague's medium for bacteriological diagnosis of dysentery. The Teague's plate is particularly valuable in a search for carriers on a large scale.

The necessity of submitting, for bacteriological diagnosis, specimens in as fresh a condition as possible is evident from the consideration of the action of the bacteriophage that strongly interferes with successful isolation of *B. dysenterix* from otherwise typical specimens of stool.

In analyzing the procedure described below for the isolation of *B. dysenterix* one can see that the principle of elimination is followed. The first step is to note the shape of the colony and the effect of the growing bacteria upon lactose, methylene blue-eosin being used as indicator; the second step is to examine for motility; the third step, which is combined with the second, is to

note the microscopic agglutination reaction; the final step is to note the behavior of the isolated culture toward carbohydrates other than lactose, principally Russell's medium, mannite, maltose, and saccharose. In arranging the procedure in this way it is possible to give early preliminary information to the interested physician. Within a few hours after the plates had been seeded (eight to ten hours) a preliminary report in certain instances could be given, by fishing out suspicious colonies, under a magnifying lens if necessary, and performing the motility and agglutination tests with serum prepared for the treatment of bacillary dysentery by immunization of horses with strains of a well-known antigenic property. At the same time, in as much as in a case of acute dysentery more than two or three suspicious colonies of the same type are found, as a rule, these are fished out and transplanted into Russell's medium and other carbohydrates. In this way a specimen delivered at the laboratory for examination for *B. dysenterix*, for instance, before 9 o'clock in the morning could be reported as suspicious macroscopically and microscopically upon receipt of the specimen and as highly suspicious bacteriologically before 5 o'clock in the afternoon, provided the shape of the colony corresponded to that of *B. dysenterix* on Teague's medium and the motility and agglutination tests agreed with a control of known *B. dysenterix* culture. Within twenty-four hours—that is, next morning—confirmatory tests of sugar reactions, which would not only indicate the presence of *B. dysenterix* but also determine the type, could be made.

Recently it was decided to subject this procedure which has been in vogue for several years in this laboratory to a revision in view of a statement made by G. R. Lacy.⁽⁴⁾ Lacy makes the following statement:

* * * The practical point which we would mention in connection with this report is that, had we depended upon the immune serum of typical Shiga alone for diagnosis of these organisms, we should have missed eighteen out of the forty-five and, even with the sera of the two fixed groups, we should still have missed nine of the forty-five, or practically 20 per cent. We feel, therefore, that the use of cultural, biological, and serological methods should always be employed in studying this group of organisms.

It is obvious that tests other than mere serologic must be used for classification of pathogenic bacteria. The study of Lacy on

serologic differences of grouping brings out this point very clearly. We must, however, emphasize the differences between the serum as prepared by Lacy for his study and the serum as prepared by us for therapeutic purposes and, incidentally, used for diagnostic purposes in the laboratory. The first difference is that, while Lacy used small laboratory animals, rabbits, our serum is derived from immunized horses. The second difference is that, while Lacy used a high dilution in order to bring out the differences, we are using for diagnostic work a low dilution in order to avoid these differences in dysentery strains. Furthermore, the serum prepared by us is so polyvalent with regard to Shiga strains that it affects all known strains of *B. dysenteriae* investigated, including those found by Lacy to belong to three different groups. (8) The fact that Lacy found our serum to protect laboratory animals against subsequent infection with strains, no matter to which serologic group of his classification (4) they belong, is an indication of the polyvalency of our horse serum. The explanation lies mainly in the findings on antigenic properties of various strains of *B. dysenteriae* as a basis for serologic grouping (8) and in the use of a different donor of immune serum.

There is a further difference between the material experimented on by Lacy and the material we used. While we used specimens from patients, carriers, or autopsies, Lacy examined the series of forty-five strains designated as *B. dysenteriae* by laboratories in various countries. In other words, the majority of his cultures were stock cultures, not freshly isolated strains.

The serologic differences particularly evident in absorption experiments of artificially reproduced mutants have been sufficiently brought out by Morishima. (5) Therefore, the conclusion drawn by Lacy from his experiment does not directly apply to the identification of strains isolated from specimens, particularly in acute cases, when horse serum prepared by immunization against strains of permanently good antigenic property is used.

TECHNIC

Selection of material for examination.—The specimen submitted for examination was placed on a sterile Petri dish. With the tip of a sterile platinum loop a portion of the material containing mucus was picked up and washed in a tube of distilled water. This washed portion constituted the material for inoculation on the lactose methylene blue-eosin agar plates.

The samples were plated on lactose methylene blue-eosin agar by spreading the washed faecal material over the plates. The plates were incubated overnight (37° C.). The next day suspicious colonies were marked. These colonies were somewhat transparent, of a pinkish color, and had irregular edges. From these colonies motility test and agglutination test with undiluted and diluted (1 : 50) antidysenteric or typhoid and paratyphoid serum were made. A modification of Barber's isolating chamber(1) was used for this purpose. This chamber is prepared by fastening strips of glass to a slide with Canada balsam, as shown in fig. 1. The chamber used by us was 7 centimeters long, 4 centimeters wide, and 0.75 centimeter high. To examine the suspicious colonies for motility the following procedure was observed. A cover glass large enough to cover the chamber completely was prepared as suggested by Barber; that is, a little vaseline was carefully smeared on the slide, after which the cover glass was thoroughly polished. This was done to prevent the drops from running together. Then drops of salt solution were placed on the cover glass by means of a platinum loop. With a straight platinum wire, a bit of each suspicious colony was picked up and emulsified in two drops of salt solution, so that there were two drops of bacterial emulsion for each colony, arranged as seen in fig. 2.

The cover glass was then turned over and rested on the chamber, the drops downward, as in fig. 3.

The drops were examined under the microscope for motility and the result was recorded. Then the agglutination tests were made. Nonmotile bacilli were tested out with antidysenteric serum, while motile bacilli were tested with typhoid and paratyphoid A serum. The procedure was as follows: On the side of the first drop of bacterial emulsion a drop of pure antidysenteric serum or antityphoid serum, as the case may be, was placed. On the side of the second drop of bacterial emulsion, a drop of a 1 : 50 dilution of serum was placed (see fig. 4). Then, with a platinum wire, the drops were joined as indicated in fig. 5.

The cover glass was put in a wet chamber, the drops upward. This consisted of a Petri dish, on the bottom of which a piece of wet filter paper was placed to prevent drying up of the drops on the slide, and two pieces of glass tubing on which the cover glass rested (fig. 6). The glass tubing was filled with water, thus supplying the moisture necessary to keep the filter paper wet.

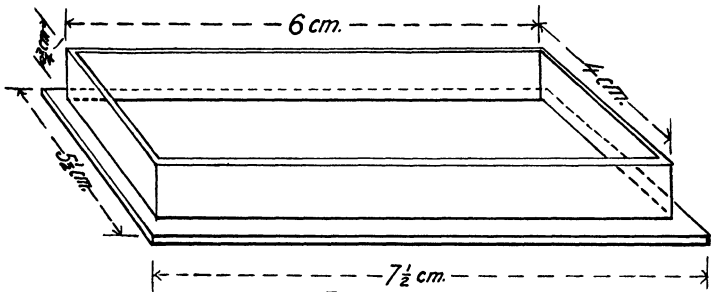


FIG. 1

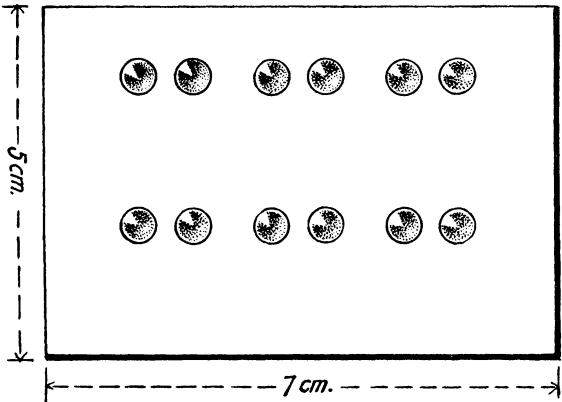


FIG. 2.

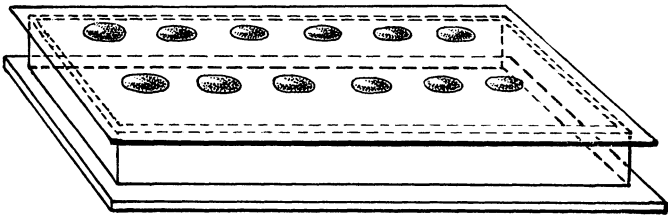


FIG. 3.

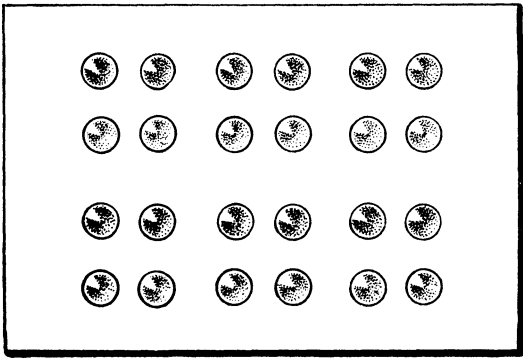


FIG. 4.

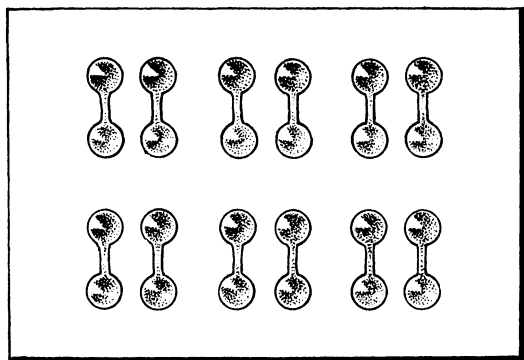


FIG. 5.

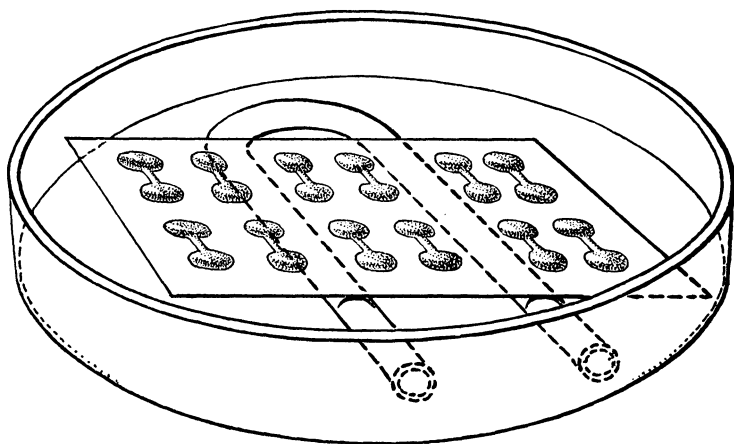


FIG. 6.

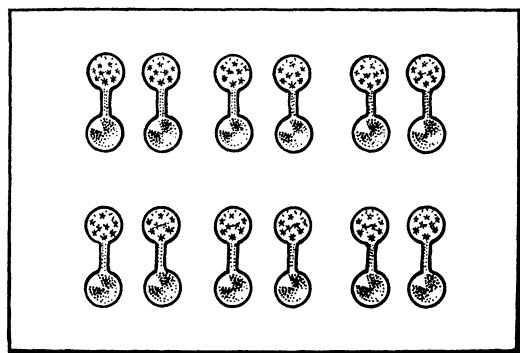


FIG. 7.

The wet chamber, with the cover glass in it, was left in the incubator for about twenty to thirty minutes. Then the slide was carefully removed and turned over on the chamber, the drops downward, and examined under the microscope. Clumps of bacteria at the union point of the two drops showed that agglutination was positive (fig. 7). The far end of the drop of bacterial emulsion, where serum did not reach, served as control. Motile bacilli which did not agglutinate in typhoid serum were tested out separately with paratyphoid A serum. Results were recorded.

Besides the agglutination tests performed with the colonies found suspicious on lactose methylene blue-eosin plates, these colonies were simultaneously transferred into Russell's medium and incubated for twenty-four hours. Results were recorded as follows: The tubes which showed much gas production and in which the medium was completely acidified were marked negative and discarded. Those which had no gas and in which the butt was acid were considered suspicious and were recorded as + Russell. Those which had gas but in which only the butt of the tube was acid were recorded as + and suspicious for paratyphoid A. The growth in Russell's tubes was then transferred into other carbohydrates to verify results and to determine the type of dysentery. The carbohydrates used for this purpose were glucose, mannite, maltose, xylose, dulcitol, lactose, saccharose, and litmus milk.

Nonmotile bacilli, agglutinable in polyvalent antidysenteric serum 1:50 fermenting glucose alone or sometimes glucose and maltose (nonmannite fermenter), were reported positive for *B. dysenteriae* Shiga. Nonmotile bacilli, agglutinable in polyvalent antidysenteric serum fermenting glucose, mannite, and maltose, but not lactose, were recorded as positive for *B. dysenteriae* Flexner.

Motile bacilli, agglutinable by antityphoid serum, non-gas producer, fermenting glucose, mannite, and maltose, and turning lead acetate paper black, were recorded positive for typhoid.

Motile gas-producing bacteria fermenting glucose, mannite, maltose, and dulcitol, and agglutinated by paratyphoid serum, were reported as positive for paratyphoid A.

SUMMARY OF RESULTS

1. Time of study, one year.
2. The number of specimens received for bacteriological examination in the search for *B. dysenteriae*, *B. typhosus*, and *B. para-*

typhosus A in patients, healthy persons, and cadavers, and that were plated on lactose methylene blue-eosin agar, was 24,251; out of this number of specimens 441 were found suspicious on lactose methylene blue-eosin agar for either *B. dysenterix*, *B. typhosus*, or *B. paratyphosus* A.

3. Number of specimens found suspicious on lactose methylene blue-eosin agar for *B. dysenterix*:

Patients	66
Healthy persons:	
Food handlers	113
Contacts	50
Cadavers	6
Total	235

4. Number of specimens found suspicious for *B. typhosus* and *B. paratyphosus* A:

Patients	42
Healthy persons:	
Food handlers	101
Contacts	50
Cadavers	13
Total	206

5. Number of specimens obtained from patients and found suspicious on lactose methylene blue-eosin agar for either *B. dysenterix*, *B. typhosus*, or *B. paratyphosus* A, 108.

6. Number of specimens obtained from carriers and found suspicious on lactose methylene blue-eosin agar for either *B. dysenterix*, *B. typhosus*, or *B. paratyphosus* A:

Food handlers	214
Contacts	100
Total	314

7. Number of specimens obtained from cadavers and found suspicious on lactose methylene blue-eosin agar for either *B. dysenterix*, *B. typhosus*, or *B. paratyphosus* A, 19.

8. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. dysenterix*:

Patients	41
Healthy persons:	
Food handlers	11
Contacts	6
Cadavers	3
Total	61

9. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. typhosus*:

Patients	5
Healthy persons:	
Food handlers	0
Contacts	0
Cadavers	0
Total	5

10. Number of specimens found suspicious on lactose methylene blue-eosin agar and confirmed as positive for *B. paratyphosus A*:

Patients	4
Healthy persons:	
Food handlers	11
Contacts	4
Cadavers	2
Total	21

TABLES SHOWING THE RESULTS OF PRELIMINARY AND CONFIRMATORY TESTS OF BACILLUS DYSENTERIÆ, *B. TYPHOSUS*, AND *B. PARATYPHOSUS A*

FIGURES IN TABLES 1 TO 11 MEAN NUMBER OF SPECIMENS GIVING RESULTS CONFORMING WITH THE TESTS INDICATED ON THE LEFT OF EACH TABLE

TABLE 1.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.	
				Food handlers.			Contacts							
	<i>B. dysenteriae</i> .	<i>B. typhosus</i> .	<i>B. paratyphosus A</i> .	<i>B. dysenteriae</i> .	<i>B. typhosus</i> .	<i>B. paratyphosus A</i> .	<i>B. dysenteriae</i> .	<i>B. typhosus</i> .	<i>B. paratyphosus A</i> .	<i>B. dysenteriae</i> .	<i>B. typhosus</i> .	<i>B. paratyphosus A</i> .	<i>B. dysenteriae</i> .	<i>B. typhosus</i> and <i>B. paratyphosus A</i> .
Agglutination 1 : 1, positive.....	41	5	4	11	0	11	6	0	4	3	0	2	61	26
Agglutination 1 : 50, positive.....	41	5	4	11	0	11	6	0	4	3	0	2	61	26
Confirmatory, positive.....	41	5	4	11	0	11	6	0	4	3	0	2	61	26

TABLE 2.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.	
				Food handlers.			Contacts.							
	<i>B. dysentericæ.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysentericæ.</i>	<i>B. typhosus A.</i>	<i>B. paratyphosus A.</i>	<i>B. dysentericæ.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysentericæ.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysentericæ.</i>	<i>B. typhosus and B. paratyphosus A.</i>
Agglutination 1 : 1, positive.....	0	2	0	0	1	0	1	0	0	0	0	0	1	3
Agglutination 1 : 50, positive.....	0	2	0	0	1	0	1	0	0	0	0	0	1	3
Confirmatory, negative.....	0	2	0	0	1	0	1	0	0	0	0	0	1	3

TABLE 3.

Results of tests.	Specimens from patients.	Specimens from healthy persons.		Specimens from cadavers.	Total.
		Food handlers.	Contacts.		
Agglutination 1:1, positive.....	0	0	0	0	0
Agglutination 1:50, negative.....	0	0	0	0	0
Confirmatory, positive.....	0	0	0	0	0

TABLE 4.

Results of tests.	Specimens from patients.		Specimens from healthy persons.				Specimens from cadavers.		Total.	
			Food handlers.		Contacts.					
	<i>B. dysenteriae.</i>	<i>B. typhosus and B. paratyphosus A.</i>	<i>B. dysenteriae.</i>	<i>B. typhosus and B. paratyphosus A.</i>	<i>B. dysenteriae.</i>	<i>B. typhosus and B. paratyphosus A.</i>	<i>B. dysenteriae.</i>	<i>B. typhosus and B. paratyphosus A.</i>	<i>B. dysenteriae.</i>	<i>B. typhosus and B. paratyphosus A.</i>
Agglutination 1 : 1, positive.....	19	1	76	14	34	15	3	1	132	31
Agglutination 1 : 50, negative.....	19	1	76	14	34	15	3	1	132	31
Confirmatory, negative..	19	1	76	14	34	15	3	1	132	31

TABLE 8.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>
Russell, positive.....	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Other carbohy- drates, positive.....	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21

TABLE 9.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>
Russell, positive.....	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Other carbohy- drates, negative....	5	3	2	10	0	17	7	11	12	0	0	1	22	4	32

TABLE 10.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>
Agglutination, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Russell, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21
Other carbohydrates, positive	41	5	4	11	0	11	6	0	4	3	0	2	61	5	21

TABLE 11.

Results of tests.	Specimens from patients.			Specimens from healthy persons.						Specimens from cadavers.			Total.		
				Food handlers.			Contacts.								
	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>	<i>B. dysenteriz.</i>	<i>B. typhosus.</i>	<i>B. paratyphosus A.</i>
Agglutination, positive.....	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Russell, positive.....	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32
Other carbohydrates, negative.....	5	3	2	10	0	17	7	1	12	0	0	1	22	4	32

SUMMARY OF TABLES

Out of 24,251 specimens examined, 441 were found suspicious on lactose methylene blue-eosin agar plates for either dysentery, typhoid, or paratyphoid.

Table 1 gives the total number of specimens found positive for either dysentery, typhoid, or paratyphoid A, in both preliminary and confirmatory tests.

In Table 2, however, we find that a small number of specimens were positive on agglutination in both undiluted and diluted serum, but the result was negative on the confirmatory examination.

Not a single specimen, however, was found to give positive agglutination in undiluted serum, negative in diluted serum, and positive in confirmatory tests, as seen in Table 3.

Table 4 shows a number of specimens positive by agglutination with undiluted serum, but negative with diluted serum and in the confirmatory test.

Table 5 shows an important point; namely, not one of the specimens that would be negative on agglutination test with either diluted or undiluted serum would be found positive in the confirmatory test.

Table 6 shows a small number of specimens positive in agglutination in undiluted serum, slightly agglutinable in diluted serum, but negative in the confirmatory test.

Table 7 shows the number of specimens which gave suspicious colonies on lactose methylene blue-eosin agar plates but turned out to be negative in the agglutination and the confirmatory tests for either dysentery, typhoid, or paratyphoid A.

Table 8 shows that all specimens found positive in the confirmatory tests for either dysentery, typhoid, or paratyphoid A were positive in Russell's medium.

Several specimens were found positive in Russell's medium but resulted negative in other carbohydrates, as seen in Table 9.

Table 10 shows specimens which were positive in agglutination in Russell's and other carbohydrates. This table gives the same numbers as do Tables 1 and 8.

Table 11 shows a number of specimens which, although positive on agglutination and in Russell's, resulted negative in other carbohydrates.

CONCLUSION

From the tables it can be seen that, besides the number of specimens which were positive in both preliminary and confirmatory tests, there were some that, although positive in the preliminary tests, resulted negative in the confirmatory tests. On the other hand, however, none was found negative in the preliminary tests and positive in the confirmatory tests. So the error of the procedure here discussed lies on the safe side.

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3. HAUGHWOUT, FRANK G., and GEORGE R. CALLENDER. Dysentery: Its diagnosis and management through the microscope. *Internat. Clin.* XXXV 2 (1925) 130-140. Frontispiece and 32 pls., 31 refs.
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5. MORISHIMA, KAN-ICHIRO. Experimental inquiry into the constancy of types of *Bacillus dysenteriae*. *Philip. Journ. Sci.* 29 (1926) 447.
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ILLUSTRATIONS

TEXT FIGURES

FIGS. 1 to 7. Showing apparatus used in making microscopic tests for *B. dysenteriae*, *B. typhosus*, and *B. paratyphosus A*.

THE PHILIPPINE SIGANIDS

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SIX PLATES

SIGANIDÆ¹ (TEUTHIDIDÆ)

Dorsal XIII-10; anal VII-9.

The oblong, strongly compressed form has a thick, leathery skin, covered with very small, closely adherent, cycloid scales, the caudal scaled, the other fins naked; the peculiar physiognomy is characteristic; the small mouth has one row of small, narrow, serrated cutting incisors in each jaw; the vomer and palatines are toothless; the dorsal fin is continuous, the spinous portion longer than the soft part; the dorsal and anal spines are strong, heteracanthous—that is, alternately strong and weak on the right and left sides; a sharp spine projects forward from the first interneural at the base of the first dorsal spine and pierces the skin at the nape, forming a prostrate spine; rarely it is concealed; the thoracic ventrals are unique, unlike those of any other fish, each with an outer and an inner spine, and with three soft rays between, I-3-I; the caudal fin is more or less lunate, never truncate. The gill membranes are not united, attached to the isthmus; pseudobranchiæ well developed; branchiostegals 5; the long intestine is much convoluted, with 5 or 6 pyloric cæca; the large air bladder is forked before as well as behind; vertebræ $10 + 13 = 23$. The skeleton has a number of peculiarities; the maxillary and premaxillary are firmly united, the lower pharyngeals but little developed; the abdominal cavity is surrounded by a complete ring of bones, the hypocoracoid extending backward the whole length of the abdomen and joined posteriorly to a spinous process of the first interhæmal; the long slender pubic bones are firmly attached to each other, with no free space between them.

¹ Starks, E. C., On the relationship of the fishes of the family Siganidæ, Biol. Bull. Marine Biol. Lab. Woods Hole 13 (1907) 211.

The family shows numerous peculiarities and stands rather far from any other known, but is apparently more closely related to the Acanthuridæ than to any other group. It is confined to the tropical parts of the Indian and Pacific Oceans, one species ranging northward to Japan. But two genera are known. The Siganidæ are small to moderate-sized fishes, not exceeding 400 millimeters in length, all herbivorous. The tail is unarmed, but they can inflict grievous wounds with their dorsal, anal, and ventral spines. They live about submerged reefs, feeding on the submarine pastures in great schools, like flocks of sheep. The larger species are excellent food fishes, the firm flaky flesh being well flavored. Some of them are dull colored, but a few kinds are very handsome.

Vast shoals of siganid fry approach the coast of Camarines Sur and Sorsogon each year, and are caught by the coast dwellers in large quantity. These fry are made into the fermented product called *guinamos* by the Bicol and Visayans, and *bagoong* by the Ilocanos. A similar phenomenon occurs on the coast of Pangasinan about Cape Bolinao.

Key to the Philippine genera of Siganidæ.

- a*¹. Snout slender, elongate, tubular..... Lo.
*a*². Snout of ordinary shape, not elongate or tubular..... Teuthis.

Genus TEUTHIS Linnaeus

Teuthis LINNÆUS, Syst. Nat. ed. 12, 1 (1766) 507.

Siganus FORSKÅL, Descr. Anim. 10 (1775) 25.

The characters of the genus are included in the family diagnosis. About 30 nominal species are known, of which 15 are here described from the Philippines. A. B. Meyer collected in 1872 at Cebu a siganid which was determined as *Teuthis lurida* Rüppell, and published by him under that name in the Annales of the Natural History Society of Spain. This determination was probably an error, as *Siganus lurida* is otherwise known only from the Red Sea. Meyer's specimen was probably *S. fuscescens*. Some of the species are very handsomely colored or characteristically marked, but in most cases their colors disappear rapidly in alcohol. As the structure in this very natural genus presents but trifling differences, the determination of preserved specimens is often a matter of much difficulty.

Vernacular names: Bicol, *batawayi*, *turus*; Ibanag, *malaga*; Ilocano, *barangan*; Tagalog, *samaral*; Tao Sug and Samal, *bel-*

long, indongan; Visayan, *dayagbagu, danguit, layap, mandalada, samaral, tayog*.

Siganid fry are called *kuyug* in the Bicol language; *padas* in Pangasinan.

Key to the Philippine species of Teuthis.

*a*¹. No broad diagonal dark bands on head, no well-marked transverse bands or lines, and no extended longitudinal lines.

*b*¹. No large dark spot on shoulder.

*c*¹. Color uniform brown or mottled with darker brown; usually a few dark brown spots scattered over sides; caudal not deeply forked, barred with brownish; dorsal and anal rays not spotted.

T. fuscescens.

*c*². More or less spotted with paler.

*d*¹. A large dark spot below dorsal rays; body with large spots, often hexagonal, golden or brown, rarely pale; three diagonal lines on side of head below eye, downward and forward.

T. concatenata.

*d*². No large dark spot below dorsal rays.

*e*¹. Anterior and ventral parts and caudal peduncle covered with dark-edged, bluish, pearly ocelli, reduced to small dark spots or dots on trunk..... *T. corallina.*

*e*². Sides with rounded spots or short curved streaks, golden in life, often disappearing; caudal deeply forked, indistinctly barred with brown; dorsal and anal rays brown-spotted.

T. rostrata.

*b*². A large dark spot on shoulder.

*f*¹. Head and body covered everywhere with large rounded or hexagonal golden or brown spots, larger than interspaces.

T. hexagonata.

*f*². Spots smaller than interspaces.

*g*¹. Head and body with many pale spots, rounded and smallest on nape and dorsally, larger and oval or elongate on middle and ventrally; a blackish spot on top of eye; caudal not deeply forked..... *T. oramin.*

*g*². Entire body and fins dark purplish brown with a minute pearl white dot on each scale; caudal deeply forked..... *T. sutor.*

*a*². Broad diagonal dark bands on head, or body with well-defined transverse or longitudinal bands or lines.

*h*¹. A broad dark brown band from nape over eye to lower jaw.

*i*¹. Six undulate transverse blue bands anteriorly on body, longitudinal blue bands posteriorly, or blue bands broken and represented by dots..... *T. puella.*

*i*². A broad dark brown band from base of fourth to seventh dorsal spines to base of pectoral; both diagonal bands edged with bluish; top of head and interorbital with transverse blue or dark lines.

T. virgata.

*h*². No broad diagonal band on head.

*j*¹. Transverse lines or bands on trunk.

*k*¹. Side with over twenty vertical bluish lines, often looped above and below, the anterior and posterior ones bent below and running back lengthwise below middle of side..... *T. doliata*.

*k*². Body with four broad transverse undulate dusky bands.

T. tetrazona.

*j*². Sides with longitudinal lines.

*l*¹. Lines not vermiculated.

*m*¹. Bluish white lines along abdomen, passing into oblong elongate spots on middle of side and more or less rounded spots along back..... *T. javus*.

*m*². Nine or ten broad brown lines along side, forming isles and knots along back, interrupted on belly and passing into spots near anal; a large yellow spot under soft dorsal, sprinkled with black dots and circled by red..... *T. lineata*.

*l*². Lines vermiculated.

*n*¹. Depth 2.5 to 3 times in length; body covered with vermiculated bluish lines often reticulated, sinuously longitudinal along side; a dark crossband with narrow clear margins on base of caudal peduncle; caudal not spotted.... *T. striolata*.

*n*². Depth 1.9 to 2 times in length; entire head and body covered with vermiculate bluish white longitudinal lines; caudal fin spotted *T. vermiculata*.

TEUTHIS FUSCESCENS (Houttuyn). Plate 1, fig. 1.

Centrogaster fuscescens HOUTTUYN, Acta Soc. Haarl. 20 (1782) 333.

Amphacanthus fuscescens CUVIER and VALENCIENNES, Hist. Nat.

Poiss. 10 (1835) 115; SCHLEGEL, Fauna Japonica, Pisces 127 (1842) pl. 68, fig. 1.

Teuthis fuscescens GÜNTHER, Cat. Fishes 3 (1861) 321; (?) JORDAN and METZ, Mem. Carnegie Mus. 6 (1913) 44.

Siganus fuscescens JORDAN and FOWLER, Proc. U. S. Nat. Mus. 25 (1902) 560, pro parte; EVERMANN and SEALE, Bull. Bur. Fisheries

26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907)

247; SEALE, Philip. Journ. Sci. § D 5 (1910) 284; FOWLER, Proc.

Acad. Nat. Sci. Phila. 70 (1918) 69; FOWLER and BEAN, Proc.

U. S. Nat. Mus. 62 (1922) 58.

? *Teuthis lurida* MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 22.

The slightly elongate body compressed and ovoid in form, upper and lower profiles about equally elevated and uniformly curved from snout to caudal peduncle, the greatest depth 2.5 to 2.6 in length; head a little longer than deep, 3.9 to 4.1 in length of body, its upper profile obtuse and very slightly arched; the slightly convex interorbital space widest in front, where there is a slight protuberance, its least width 3.2 to 3.5 in head; the diameter of the rounded eye 2.8 to 3.2 in head; the obtuse snout

2.3 to 2.4 times in head and 1.5 times maxillary, which is 3.4 to 3.6 in head; preorbital at angle of mouth very narrow, 2.4 to 2.8 in snout; about 18 teeth on each side in both jaws; upper teeth pointed, microscopically serrate, brownish tipped; lower teeth bifid, outer portion acutely pointed, inner part wider, higher, expanded in a very thin plate with a semicircular top; both nostrils rounded, the anterior one with a wide, rather high fleshy flap on its posterior margin, and the other a simple rounded opening; anterior edge of orbital ring finely serrated; preopercle margin entire, opercle unarmed; least depth of caudal peduncle 3.9 to 5.7 in length of head.

Only the cheek, and the uppermost portions of preopercle and opercle scaled, rest of head naked; caudal fin scaly and the other fins naked; middle dorsal spines highest, the last one 3 to 3.4 in head; anal spines increase in height to the third, from which they become lower to the last which is 2.5 to 3 in head; soft dorsal broadly rounded, its second and third rays highest, 1.9 to 2.1 in head; soft anal lower than dorsal, the rays decreasing in height posteriorly; the lunate caudal equals or is usually a little longer than head, 3.6 to 5 in length, 1.4 to 1.7 in depth, the upper lobe the longer; pectoral much shorter than caudal fin, 1.3 to 1.4 in head and 1.3 to 1.5 times ventral which extends but little beyond anus; outer ventral spine 3 to 3.25 in head, a little longer than inner one, which is 1.5 to 1.7 in pectoral.

The ground color of alcoholic specimens almost uniform brown, usually with a few dark brown spots scattered over sides of head and trunk, the dorsal region often darker, breast and posterior ventral region sometimes paler; some specimens have the sides mottled with darker brown; dorsal and anal clouded with brownish; caudal fin distinctly marked by brownish bars; pectoral uniform yellowish, ventral brownish.

This species is very abundant in some parts of the Philippines. The Bureau of Science collection contains 107 specimens, 25 to 170 millimeters long, from the following localities:

Higad, Camarines Sur, 4.
San Miguel Bay, Camarines
Sur, 4.
Bacon, Sorsogon, 93.

Bantayan Island, 2.
Dumaguete, Oriental Negros, 2.
Sandakan, Borneo, 2.

The specimens from Higad, and 91 of the specimens from Bacon are from 25 to 30 millimeters long. Vast shoals of

kuyug, as the Bicolans call the fry of this fish, approach the coasts of Sorsogon and Camarines Sur annually, during April and May. Large quantities are caught and preserved with salt to make *guinamos*. Our Philippine specimens all agree with Schlegel's figure except for the brownish crossbars on the caudal. The Sandakan specimens are silvery on the belly.

Evermann and Seale had specimens from San Fabian, Pangasinan; Bacon, Sorsogon; and Jolo. Seale and Bean had specimens from Zamboanga, and Fowler and Bean had one from Cebu; Fowler had a "large series, mostly young," from "the Philippines." Seale obtained it at Sandakan, Borneo.

This species is common in Japan, where it is caught in large quantities at nearly all times of the year, but its flesh is little esteemed. It does not attain a length greater than about 290 millimeters. It has also been reported from Korea.

Jordan and Fowler's account of *Siganus fuscescens* (Houttuyn) includes *T. albopunctatus* (Schlegel), a synonym of *T. oramin* (Bloch and Schneider); one of their Japanese specimens, 114 millimeters long, is in the Bureau of Science collection; it is typical *T. albopunctatus*, differing from *T. fuscescens* in having the small white spots or dots on the sides and a dark shoulder spot. Small specimens of *T. fuscescens* do not show these characteristics, but are colored like the adults. Jordan and Evermann's *Siganus fuscescens* from Formosa is also *T. albopunctatus*, or *T. oramin* according to our interpretation of this species. Specimens of *T. oramin*, but 20 to 25 millimeters in length, show the characteristic markings of that species and can at all times be separated from *T. fuscescens*.

TEUTHIS CONCATENATA (Cuvier and Valenciennes). Plate 4, fig. 1.

Amphacanthus concatenatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 93; BLEEKER, Act. Soc. Sci. Indo-Neerl. 1 (1856) Beschrij. visch. Amboina, 46; WEBER, Fische Siboga Exp. (1913) 330.

Teuthis concatenata GÜNTHER, Cat. Fishes 3 (1861) 316; Fische der Südsee 1 (1873) 88; DAY, Fishes of India (1878) 167, pl. 40, fig. 4.

Siganus concatenatus JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 789.

Siganus lineatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98.

Siganus lineatus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Siganus hexagonatus SEALE, Philip. Journ. Sci. § D 5 (1910) 284.

? *Amphacanthus tetrazonus* BLEEKER, Nat. Tijds. Ned. Ind. 8 (1855) 441.

? *Siganus tetrazonus* JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

Ibanag name at Buguey, Cagayan Province, *malaga*.

Depth of the oblong, much compressed body 1.9 to 2 in length; upper profile more elevated than ventral; length of head less than its depth, 3.4 to 3.7 in length of body; the very much elevated upper profile very steep in front of interorbital space and rather obtuse behind; the least width of the slightly arched interorbital is 2.9 to 3.1 in head and is slightly exceeded by the diameter of the large rounded eye, which is 2.7 to 2.9 in head; snout 2 to 2.1 in head and 1.7 to 1.8 times maxillary, which is 3.3 to 3.7 in head and reaches to below posterior nostril; preorbital width behind angle of mouth a little less than length of maxillary and almost twice in snout or 3.9 to 4.6 in head; the anterior nostril has a fleshy marginal flap behind; anterior edge of orbital ring finely serrated; angle of preopercle finely serrated and slightly produced, forming a very shallow notch with the vertical limb; opercle has an angular point behind; least depth of caudal peduncle 3.1 to 3.3 in length of head.

Scales cover cheek, and uppermost portions of preopercle and opercle, while the rest of head is naked; no scales on any of the fins except caudal; middle dorsal spines higher than the others, the last one 1.9 to 2.1 in head; anal spines evenly graduated to the last which is the highest and contained 1.2 to 1.3 in head; dorsal and anal rays angular and of almost the same height, each 1.2 to 1.4 in head; the moderately emarginate caudal 1.6 to 1.8 in depth, 2.8 to 3.35 in length, the upper lobe slightly the longer; pectoral shorter than head, 4.4 to 4.9 in length and 1.3 to 1.5 times ventral; the latter terminates a little in front of anal fin, its outer spine 1.6 to 1.97 in head, longer than inner one which is 1.96 to 2.33 in head.

Living specimens in the Bureau of Science aquarium are bluish with rounded or hexagonal golden spots on sides, which are much larger than the brilliant silvery bluish interspaces between them; there is a large, somewhat irregular golden or brown blotch below base of posterior dorsal rays; each side of head golden, with a bright silvery bluish line below preorbital, another one across cheek, a third at outer edge of scaly portion of preorbital, and a fourth near outer edge of opercle; spinous dorsal and all of anal fin golden brown; dorsal and anal

rays and caudal spotted with brown; pectoral and ventrals nearly colorless, or pectoral very pale yellow.

A badly frightened living specimen changed its color, so that it was darker and had four very large irregular dark brown spots above the middle of the side, and four dark brown bars inclined diagonally downward and forward across the whole width of dorsal and upon back below its base, alternating with the lateral spots, and a broad brown bar from origin of dorsal across eye to top of lip and middle of snout, where it joined its fellow from the other side.

When marked in this way it was much like *T. tetrazona* (Bleeker). I doubt the validity of the last-named species and believe that it is probably only a phase of *T. concatenata*.

The colors of alcoholic specimens vary as follows:

Ground color brownish, with golden brown spots on sides, the spots much larger and darker than the interspaces between them, closer together on upper half and often hexagonal and more widely spaced on lower half, especially posteriorly; vertical fins brownish violet with darker spots on their rays; caudal fin also brownish violet, spotted with darker brown; pectoral and ventral yellowish; a deep brownish violet line on lower edge of orbital, another one across cheek, and a third along lower edge of scaly portion of preopercle.

Other specimens are yellowish brown, with paler hexagonal spots which are much larger than the interspaces between them; a large brown blotch below base of posterior dorsal rays; dorsal and anal yellowish with a few brownish spots; caudal fin also yellowish and spotted lightly with brownish violet; a dark brownish violet line present below orbital, a second one across cheek, and a third on outer margin of scaly portion of preopercle; pectoral and ventral fins yellowish.

Still other specimens which are brownish have hexagonal or rounded spots which may be either darker or lighter than the ground color; the lighter spots were undoubtedly golden in life, and the darker ones probably golden brown. Either one or both kinds of spots may be present on the same individual; the ventral half may be silvery, and all the spots dark brown.

Specimens from Luna, La Union Province, are purplish brown, more or less silvery on the belly, with rows of large pale silvery gray spots, some larger than the pupil; a large silvery white spot below soft dorsal; the characteristic lines are on side of head; dorsal, anal, and caudal dusky purplish, the soft

dorsal rays and caudal spotted with dark violet-brown; pectoral very pale yellowish, ventral nearly colorless.

In life this is a very handsome fish. Long observation of living material has shown that the species is variable, individuals differing widely in size and color of the spots and the ground color, as well as in the presence or absence and color of the large spot below the soft dorsal. The blue lines on sides of head and the spots on vertical fins are constant, but may disappear in alcohol; the caudal spots are usually present, but sometimes are absent, even in living specimens.

The Bureau of Science collection contains 31 specimens, varying from 39 to 196 millimeters in length:

Buguey, Cagayan, 2.	Bulan, Sorsogon, 1.
Luna, La Union, 3.	Guinobatan, Masbate Prov- ince, 1.
Agno River, Pangasinan, 1.	Catbalogan, Samar, 2.
Bolinao, Pangasinan, 3.	Bantayan Island, 1.
Hundred Islands, Pangasinan, 1.	Dumaguete, Oriental Negros, 2.
Iba, Zambales, 1.	Cagayan de Misamis, Minda- nao, 1.
Manila, 3.	Caldera Bay, Mindanao, 1.
Nasugbu, Batangas, 1.	Sandakan, Borneo, 4.
Puerto Galera, Mindoro, 2.	
Mangarin, Mindoro, 1.	

This species was listed from the south coast of Oriental Negros by Jordan and Seale, and under the name *Siganus lineatus* from Bacon and Bulan, Sorsogon, by Evermann and Seale, and from Aparri and Cuyo by Jordan and Richardson.

It is a handsome fish, occurring from the Andamans to the Pelew Archipelago, and is widespread in the East Indies. It attains a length of about 280 millimeters.

TEUTHIS CORALLINA (Cuvier and Valenciennes). Plate 1, fig. 2.

Amphacanthus corallinus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 101; SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Ned., Leiden 2 (1844) 10, pl. 2, fig. 2.

Teuthis corallina GÜNTHER, Cat. Fishes 3 (1861) 316; Fische der Südsee 1 (1873) 88.

Siganus corallinus JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER, Proc. Acad. Nat. Sci. Phila. 70 (1918) 69; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 58.

The oblong compressed body rather deep, 1.9 to 2.3 in length, the profiles about equally elevated; length of head equals its height, 3.4 to 3.7 in length of body; a protuberance in front of eyes gives a slightly concave outline to snout; lower profile of head slightly concave; least width of the moderately convex interorbital about equal to eye, which is 3 to 3.2 in

head; snout 1.8 to 2 in head and twice the maxillary, which is 3.8 to 4 in head, its posterior end below anterior nostril; width of preorbital at angle of mouth 1.6 to 1.8 in length of snout; anterior nostril very small and circular, posterior one a little larger and covered in front with a fleshy membrane; angle of preopercle not much prolonged, its edge having fine serræ which are inconspicuous in some examples; front edge of orbital margin rather indistinctly serrated; opercle unarmed behind; least depth of caudal peduncle 3.3 to 4 times in head.

Top of head almost entirely naked; no scales present on interorbital space, snout, preorbital, lips, chin, and lower two-thirds of opercular bone; with the exception of caudal all the fins are also without scales; the middle dorsal spines higher than the rest, the last spine 1.9 to 2 in head, and lower than last anal spine, which is 1.5 to 1.8 in head; the soft portions of vertical fins angular, dorsal a trifle higher than anal, 1.5 to 1.8 in head; caudal fin deeply lunate, the lobes pointed, the upper one slightly the longer, from a little more than to a fourth longer than head, 1.3 to 1.4 in depth and 2.77 to 3.17 in length; the broad pectoral shorter than head, 4 to 4.2 in length and 1.2 to 1.5 times ventral, which extends about halfway between anus and origin of anal fin; inner ventral spine much shorter than outer one, 1.7 to 2 in pectoral, outer spine 1.6 to 1.9 in head.

In alcohol specimens are violet-brown or orange brown, the fins paler to yellowish white; head, breast, belly, and region immediately behind head covered with large dark-edged violet or bluish pearly ocelli, which become much smaller and cover the trunk as deep violet or dark spots or dots, much smaller than the interspaces, larger again at base of anal and caudal; sometimes the dots extend over the fins.

We have examined 14 specimens, 96 to 229 millimeters in length, from the following localities:

Olongapo, Zambales.

Ambil Island.

Sibuyan Island.

Tagapula Island, Samar Province.

Culion Island.

Bantayan Island and Cebu, Cebu.

Dulag, Leyte Province.

Zamboanga, Mindanao.

Jolo, Sulu Province.

Jordan and Richardson recorded this species from Cagayan-cillo, Fowler from "the Philippines," and Fowler and Bean had

specimens from Zamboanga. This handsome fish was originally described from the Seychelles where, according to Cuvier and Valenciennes, it prefers to live in the madrepora corals. It occurs throughout the East Indies, from Sumatra to the Moluccas, and eastward to the Pelew Islands.

TEUTHIS ROSTRATA (Cuvier and Valenciennes). Plate 1, fig. 3.

Amphacanthus rostratus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 116; KLUNZINGER, Fische des Rothen Meeres, Verh. Zool.-Bot. Ges. Wien 21 (1871) 503.

Teuthis rostrata PLAYFAIR, Fishes of Zanzibar (1856) 50, pl. 10, fig. 2; GÜNTHER, Fische der Südsee 1 (1873) 89, pl. 60.

Siganus rostratus SEALE, Occ. Papers Bishop Museum 1 (1901) 111; Occ. Papers Bishop Museum 4 (1906) 67; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 360; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 58.

Dorsal and ventral profiles of the elongate compressed body are evenly and about equally arched from snout to caudal peduncle, the greatest depth 2.5 to 2.8 in length; head a trifle longer than deep, its upper profile very slightly arched above snout, and almost straight or a trifle concave behind it, the length 3.8 to 4.4 in total length; interorbital space moderately convex, with a shallow groove along its middle extending forward to upper jaw, its least width almost equal to eye, which is 2.8 to 3.2 in head; snout longer than eye, 2.5 to 2.6 in head; maxillary extends posteriorly to a little past vertical from posterior nostril, 1.4 in snout, and about twice the width of preorbital at angle of mouth; teeth 12 or 14 on each side, bifid, outer lobe large, pointed, microscopically serrate, inner lobe very small, pointed; both nostrils rounded, the anterior one having a very high fleshy flap behind and the posterior one a fleshy membrane in front partly covering the opening; front edge of orbital ring finely serrated; preopercular angle entire and slightly produced; a rather conspicuous flat weak spine at posterior margin of opercle; least depth of caudal peduncle 4.3 to 5.3 in head.

Dorsal spines rather weak, the middle ones higher than the rest, the last being the lowest, 4.8 to 5.4 in head; anal spines decrease in height from second or third, the last one much lower than the first and contained 3.8 to 4.8 in head; dorsal and anal rays decrease in height to the last, the dorsal rays slightly the higher, 2.1 to 2.3 in head; caudal deeply forked, the upper lobe

the longer, a tenth to a fourth longer than head, or equal to head in small specimens, 3.4 to 3.75 in length and 1.3 to 1.4 in depth; pectoral shorter than head, in which it is contained 1.3 to 1.43 times; longest ventral ray a trifle longer than outer spine, which is 1.83 to 1.94 in head; inner spine shorter than outer one, 2 to 2.3 in head.

Alcoholic specimens violaceous brown, paler and more or less silvery beneath, sides with rounded spots or short curved streaks which were golden yellow in life, or the markings disappearing entirely; spinous dorsal and anal rather pale with brownish violet blotches, the rayed portions yellowish with brownish spots; caudal fin rather indistinctly barred with transverse brown bands; the pectoral is yellow and the ventral has some brownish violet blotches.

Here described from seven specimens, 90 to 190 millimeters in length, from the following localities: Balabac, 2; Samal Island, Davao, 1; Zamboanga, Mindanao, 4.

Jordan and Richardson had a specimen from Fuga Island, north of Luzon, and Fowler and Bean had four from Zamboanga.

Seale's color notes on a fresh specimen at Zamboanga are as follows: General color dusky blue with golden longitudinal lines more or less broken up into round spots, smaller than the interspaces, and becoming vertical behind the head; sides of head violet blue with ten irregular golden lines below eye; four brown crossbands on throat; dorsal bluish mottled with yellowish and dull brown, anal similar; pectoral golden; ventral bluish with some brownish blotches on the membrane; caudal grayish, barred marginally with darker.

The life colors of a Samoan specimen were sky blue, darker above, vermiculated with golden; dorsal mottled olive; caudal dusky, paler behind; anal dusky; ventral gray, barred with dark olive; pectoral golden.

This species, first collected in the Red Sea and afterward at Zanzibar, is not rare in the Society, Samoan, Gilbert, and Pelew Islands. It occurs also at Guam, the New Hebrides, the Solomon Islands, and Tubuai, one of the Austral Islands.

TEUTHIS HEXAGONATA (Bleeker). Plate 2, fig. 1.

Amphacanthus hexagonatus BLEEKER, Nat. Tijds. Ned. Ind. 7 (1854) 41; WEBER, Fische Siboga Exp. (1913) 328.

Teuthis hexagonata GÜNTHER, Cat. Fishes 3 (1861) 320; Fische der Südsee 1 (1873) 89.

Siganus hexagonata SEALE, Occ. Papers Bishop Museum 1 (1901) 111.

Siganus punctatus JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 360.

Depth of the oblong compressed body 2 to 2.2 in length; anterior dorsal and ventral profiles evenly and strongly convex, or upper profile steeper than ventral, or upper profile somewhat sinuous and lower in a bold uniform curve; head a little deeper than long, its upper profile a little steep and very slightly arched, 3.4 to 4 in total length; interorbital space markedly convex, its least width 2.9 to 3.2 in head and slightly greater than eye which is contained 3.1 to 3.6 times; snout 2 to 2.1 in head and 1.7 to 1.9 times maxillary, which is 3.5 to 3.9 in head and ends posteriorly below posterior nostril; width of preorbital at angle of mouth a trifle less than length of maxillary, 3.7 to 4.3 in head; anterior nostril small and rounded, having a fleshy rim which is highest posteriorly; posterior nostril a little larger and partly covered in front with a fleshy membrane; anterior edge of orbital margin distinctly serrated; angle of preopercle is slightly produced and forms a very shallow notch with the vertical limb, its edge entire; the opercle has an angular point at its hind edge; least depth of caudal peduncle 3.1 to 3.6 in head.

Head naked except on cheek, and on uppermost portions of preopercle and opercle; all the fins with the exception of caudal also naked; dorsal spines strong, the middle ones highest, the last one 2 to 2.5 in head; the very strong anal spines increase in height toward the last, which is 1.6 to 2 in head; soft dorsal and anal angular to angulose-rounded, of equal height, 1.3 to 1.8 in head; caudal fin deeply notched, apex of notch rounded, the upper one of the long pointed lobes the longer, the fin usually a third or nearly a third longer than head, rarely as short as head, 2.8 to 3.4 in length; the very broad pectoral nearly as long as head, 4.4 to 4.9 in length and 2.1 to 2.4 in depth of body; longest ventral ray does not quite reach origin of anal and is slightly longer than outer spine which is 1.6 times to nearly twice in head; inner ventral spine much shorter than outer one, about 2 to 2.3 in head.

Ground color in alcohol usually varies from brown to blackish brown, sometimes bluish gray, head, trunk, caudal peduncle, and caudal fin thickly covered with many pale, yellowish, brown, to dark brown spots as large as or a little larger than the interspaces between them, but smaller than pupil; the spots may be

rounded or oblong and are often more or less hexagonal through crowding, the ground color only forming a network between them; the spots may disappear along the ventral region from behind ventrals as far back as posterior extremity of anal, but often the lower part of belly and the region above anal are densely covered with intricately convoluted and vermiculate lines; a large irregular blackish blotch on shoulder; my smallest specimen, which is from Samal Island in Davao Gulf, and 3 small specimens from Tayabas have the shoulder spot surrounded by a broad white ring; vertical fins and ventrals uniformly violet-brown or blackish brown, or the soft dorsal and anal may be spotted with darker; pectoral uniformly yellowish or yellowish brown.

A fresh specimen from Samal Island was lilac-gray, the dorsal region and caudal peduncle darker and more bluish, a pearly blue wash over all; a coral red spot on shoulder above upper end of posterior margin of opercle; the entire body, including lips and eyes, covered with rounded golden spots, those on caudal smaller than elsewhere and yellowish brown; ventral margin of caudal violet; dorsal dusky brown, covered with reddish brown spots, the spinous part with a colorless margin, soft dorsal spotted all over; anal dusky, rays blue, membrane unspotted except margin of soft anal which was spotted like dorsal; ventral was brownish gray, pectoral with a yellowish cast.

The Bureau of Science collection contains 22 specimens, varying in length from 46 to 265 millimeters, collected at the following places:

Bolinao, Pangasinan, 3.	Dumaguete, Oriental Negros, 1.
Olongapo, Zambales, 1.	Samal Island, Davao Gulf, Mindanao, 2.
Lucena, Tayabas, 3.	Zamboanga, Mindanao, 1.
Calabanga, Camarines Sur, 3.	Pabalbag Island, Sulu Province, 1.
Calapan, Mindoro, 2.	Sitankai, Sulu Province, 1.
Estancia, Panay, 1.	
Bantayan Island, 2.	
Cuyo Island, 1.	

This distinct and beautiful species is one of the largest siganids, reaching a length of over 300 millimeters. It was first described from Cocos Island, which lies in the Indian Ocean nearly 700 miles southwest of the western extremity of Java, and it is known from Sumatra and eastward throughout the East Indies to the Fiji and Samoan Islands. *Siganus hexagonatus* (Bleeker) may be the same as *S. punctatus* (Bloch and Schneider) after Forster's MSS., but this is doubtful. Fors-

ter's specimen came from New Caledonia and one should have ample material from that island in order to be certain just what fish he had.

TEUTHIS ORAMIN (Bloch and Schneider). Plate 5, fig. 1.

Amphacanthus guttatus var. *oramin* BLOCH and SCHNEIDER, Syst. Ichth. (1901) 207, pl. 48.

Teuthis oramin GÜNTHER, Cat. Fishes 3 (1861) 318; DAY, Fishes of India (1878) 168, pl. 40, fig. 6.

Siganus oramin JORDAN and SEALE, Proc. U. S. Nat. Mus. 38 (1905) 789; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; SEALE, Philip. Journ. Sci. § D 9 (1914) 73.

Amphacanthus oramin WEBER, Fische Siboga Exp. (1913) 329.

Amphacanthus margaritiferus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 109.

Teuthis margaritifera GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 167, pl. 40, fig. 5.

Amphacanthus dorsalis BLEEKER, Verh. Bat. Gen. 23 (1850) 9.

Amphacanthus albopunctatus SCHLEGEL, Fauna Japonica, Pisces (1842) 128; KNER, Reise Novara, Fische (1865) 206.

Teuthis albopunctata GÜNTHER, Cat. Fishes 3 (1861) 318; Fische der Südsee 1 (1873) 88.

Siganus albopunctatus SEALE, Philip. Journ. Sci. § D 5 (1910) 284.

Local name at Iba, Zambales, *titang*.

Body moderately deep to slightly elongate, with dorsal and ventral profiles evenly and about equally arched from snout to caudal peduncle, depth 2.4 to 2.7 in length; upper profile of head a steep, straight, or nearly straight line from origin of dorsal to eye or beyond, thence convex to tip of snout; length of head a trifle greater than its depth, 3.8 to 4.1 times in total length; the least width of the slightly convex interorbital space a little less than eye, which is 2.6 to 3.4 in head; snout longer than eye, 2.4 to 2.6 times in head; the maxillary, which ends posteriorly a little past the vertical from posterior nostril, is 3.1 to 3.6 in length of head or 2 to 2.3 times width of preorbital at angle of mouth; two small nostrils in front of each eye, the anterior one more rounded and having a rather low fleshy flap on its posterior border; anterior border of orbital ring is finely serrated and has a rather sharp spine above it; the slightly produced angle of preopercle finely serrated; two flat weak spines at posterior edge of opercle; least depth of caudal peduncle 3.9 to 4.5 in head.

A few scales on cheek, and uppermost portions of opercle and preopercle, the rest of head naked; third to seventh dorsal spines higher than the rest, last spine rather low, 3.4 to 4.3 in head; second, third, and fourth anal spines highest, the last

one 2.5 to 3.4 in head; soft dorsal higher than anal rays, second or third ray highest, 2 to 2.4 in head; anal rays decrease in height from first or second, which is 2.4 to 2.7 in head; caudal more or less emarginate, sometimes appearing deeply forked when relaxed but never so when expanded, tips of lobes acute, the upper the longer; the fin longer than head, 3.45 to 3.75 in length, 1.3 to 1.5 in depth of body and 1.4 to 1.6 times pectoral, which is 1.25 to 1.35 in head; ventral fin extends halfway between anus and anal fin, its longest ray as long as or longer than outer spine, which is 1.78 to 1.94 in head; inner ventral spine 2 to 2.3 in head.

A fresh specimen was drab-gray, head and body thickly sprinkled with small yellowish white spots; dorsal and anal bluish, clouded with yellowish, spines gray, the yellowish rays spotted with brown, forming crossbars; caudal yellowish, with brown crossbars, tip dusky; ventral bluish, pectoral yellow; two dark crossbars on chin.

Another specimen was very light gray with a slight wash of yellowish, and pale bluish spots about half the size of pupil scattered all over head and body; three brown bars over throat and under chin; spinous dorsal bluish, spines gray, soft dorsal bluish, rays yellowish with brown blotches forming crossbars; spinous anal blue, barred with brown, soft anal yellowish, with four oblique crossbars of brown spots on rays; the yellowish caudal darker at tip and crossbarred with brown; pectoral yellowish, ventral bluish, with two pale brown crossbars.

A specimen sketched in color by the late T. S. Espinosa was grape green on sides and deep grape green along dorsal region, becoming olive yellow lower down and pale primrose yellow on breast, belly, and lower side of head; a dark spot on shoulder; entire body strewn with small pearly white spots much smaller than the interspaces, mere circular dots on nape and caudal peduncle, largest and more or less elongate along middle and lower part of body; the fins typically marked.

The color of another fresh specimen was pale brownish above, bluish below, the body covered everywhere with small pale blue spots considerably smaller than the interspaces; a yellowish brown spot on shoulder; caudal crossbarred with dark brown.

The ground color in alcohol is some shade of violaceous or plain brown or violaceous dusky, the whole body uniformly colored or the belly or lower half of body paler or silvery, snout, top and sides of head, and whole body sprinkled with many bluish

white or white or pearly spots, much smaller than the interspaces; the spots rounded and smallest on nape and along dorsal region, usually larger or much larger and more or less oval or elongate on middle and lower parts of trunk; many specimens have a few dark blackish brown rounded or irregular spots thinly scattered over sides; a large irregular dark brown blotch on shoulder; many specimens have two brown or dusky bands under chin; the spinous portions of dorsal and anal pale and clouded with brownish, the rays spotted with brownish or dusky; caudal fin with transverse bars of blackish or brown, which sometimes disappear in alcohol, especially after the lapse of some years; a blackish spot on upper edge of eye.

This species is abundant in the Philippines. We have examined 113 specimens, 20 to 218 millimeters long, from the following localities:

Burgos, Ilocos Norte, 2.	Cuyo Island, 1.
Anda, Pangasinan, 9.	Canigaran, Palawan, 1.
Bolinao, Pangasinan, 3.	Surigao, Mindanao, 4.
Iba, Zambales, 1.	Cagayan de Misamis and Misamis, Mindanao, 4.
Orani, Bataan, 1.	Caldera Bay, Mindanao, 5.
Manila, 5.	Zamboanga, Mindanao, 2.
Cavite, 1.	Davao, Mindanao, 3.
Nasugbu, Batangas, 1.	Samal Island, Davao Gulf, 16.
San Miguel Bay, 1.	Tubigan Island, Sulu Province, 2.
Calapan, Mindoro, 4.	Bato-Bato, Tawitawi, 2.
Puerto Galera, Mindoro, 3.	Balabac, 3.
Concepcion, Busuanga, 1.	Sandakan, Borneo, 1.
Despujols, Tablas, 1.	Hoihow, Hainan, 5.
Iloilo, Panay, 1.	Hongkong, 14.
Dumaguete, Oriental Negros, 6.	Amoy, China, 1.
Bantayan Island, 1.	Shimizu, Japan, 1.
Cebu, Cebu, 1.	
Inabanga, Bohol, 5.	
Borongon, Samar, 1.	

Our largest specimen is a female nearly ready to spawn, collected March 12, 1927, at Misamis, Mindanao.

This species has been recorded by Günther under the name *Teuthis albopunctata* from the Philippine Islands, and from Manila by Kner under the name *Amphacanthus albopunctatus*. Jordan and Seale had six specimens from the southern shore of Negros, and Jordan and Richardson had the fish from Aparri and Cavite.

This variable species ranges from the eastern coast of Hindustan eastward throughout the East Indies, and along the

coasts of China and southern Japan and on to Micronesia, where it is recorded from the Pelew Islands and Howland Island, which lies east of the Gilbert Islands.

We are unable to separate specimens with smaller spots from those with larger ones, or those with more deeply emarginate caudal from those with the caudal but slightly emarginate. Many of our specimens are like Day's figure of *Teuthis margaritifera*; we have none like Schneider's Plate 48, or Day's poor figure of *T. oramin*, although we have many near the latter. Specimens from Borneo and the Sulu Archipelago are exactly like a specimen from Japan.

TEUTHIS SUTOR (Cuvier and Valenciennes). Plate 2, fig. 2.

Amphacanthus sutor CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 108.

Teuthis sutor GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 167.

Depth of the compressed body 2.1 in length, dorsal and ventral profiles similar and equally curved; head as long as deep, 3.8 to 3.9 in length; the convex interorbital 3.1 to 3.2 in head and slightly wider than eye, which is 3.2 to 3.3 in head; snout 2 to 2.2 times in head and nearly twice the length of maxillary, which is 3.6 to 4.1 in head; greatest width of preorbital almost equal to eye, 1.4 to 1.6 in snout; front nostril rounded, the fleshy rim highest behind; posterior nostril is a larger opening covered with a membrane in front; preopercle finely serrated at its angle and on its inferior limb; above angle a very slight notch; orbital margin finely serrated in front; opercle has two flat spines at its hind border, a small rather inconspicuous one above gill opening and a larger one a little below it; least depth of caudal peduncle exceeds slightly greatest width of preorbital, and is 2.9 to 3.1 in head.

Scales present on cheek, and on uppermost portions of opercle and preopercle, the rest of head naked, and all the fins excepting caudal naked; last dorsal spine about as high as middle ones, 1.7 to 1.9 in head; anal spines increase in height to the last which is 1.5 to 1.6 in head; soft dorsal and anal rounded, the former slightly the higher, the longest rays 1.4 in head; caudal fin deeply forked, with falcate lobes, the upper one slightly the longer and 1.4 to 1.5 times head; pectoral fin a little shorter than head, 1.1 to 1.17 in head and 4.2 to 4.6 in length; ventral extends to origin of anal, shorter than pectoral, 1.4 to 1.6 in

length of head; outer ventral spine about a fifth longer than inner one which is 1.9 to 2 in head.

The specimens when fresh were dark purplish brown, with a minute bright pearl white dot on each scale; there was a large blackish blotch on shoulder; all the fins were also dark purplish brown. The ground coloration has not changed much in alcohol.

Here described from three fine specimens, 167 to 182 millimeters long, taken at Guintacan and Bantayan Islands.

This is the first Philippine record of this species, which has heretofore been reported only from the Seychelles, Reunion, and the coast of Malabar.

This distinct and handsome species reaches a length of at least 280 millimeters.

TEUTHIS PUELLA (Schlegel). Plate 4, fig. 2.

Amphacanthus puellus SCHLEGEL, Bijdr. Dierk. 1 (1852) 39, fig. 2; BLEEKER, Act. Soc. Sci. Indo-Neerl. 8 (1860) 36; WEBER, Fische Siboga Exp. (1913) 329.

Teuthis puella GÜNTHER, Cat. Fishes 3 (1861) 323; BLEEKER, Ned. Tijd. Dierk. 1 (1863) 156, 235, 252; 2 (1865) 190, 288; Versl. Akad. Amsterdam II 7 (1873) 37; GÜNTHER, Fische der Sudsee 1 (1873) 91.

Amphacanthus cyanotaenia BLEEKER, Nat. Tijd. Ned. Ind. 4 Nieuwe Serie, 1 (1853) 606.

Siganus zoniceps SEALE, Occ. Papers Bishop Mus. 4 (1906) 69, fig. 18.

The compressed oblong body slightly elongate, depth 2.3 to 2.5 in length, dorsal and ventral profiles about equally elevated; head as long as deep, its length 3.5 to 3.8 in length, its upper profile somewhat obtuse and very slightly arched; least width of convex interorbital 3.1 to 3.5 in head, slightly greater than eye, which is 3 to 3.4 in head; the slightly elongate snout 2 to 2.1 in head and 1.7 to 1.8 in maxillary, which terminates posteriorly a little behind anterior nostril and is about as long as width of preorbital at angle of mouth; preopercle finely serrated at angle; front margin of orbital ring denticulate; a rather obscure flat weak spine at posterior edge of opercle.

Scales present on top of head a little in front of nape, on cheek, uppermost portion of preopercle and opercle, the rest of head naked; last dorsal spine 2.3 to 3 in head, much lower than last anal, which is 1.8 to 2.1 in head; in the young the posterior spines of dorsal higher than the rest, in the adult the middle ones highest; soft dorsal 1.5 to 1.8 in head, higher than anal,

which is 1.6 to 1.8 in head; caudal fin deeply lunate, its upper lobe slightly the longer, always longer than head, 2.92 to 3.3 in length, 1.5 to 1.8 times the broad rounded pectoral which is 2 to 2.2 in depth of body and 1.25 to 1.45 in head; ventral fin extends about halfway between anus and origin of anal, its outer spine much higher than the inner one and 1.2 to 1.5 in head.

Alcoholic specimens brownish violet, with six deep brown, somewhat vermiculated transverse lines on anterior portion of trunk and with longitudinal streaks of a like color posteriorly; a broad dark brown band crosses obliquely forward from nape over eye to lower jaw; on the upper portion of this band above eye are some darker or black spots, and behind it on preopercle a few brownish spots; fins yellowish to yellowish brown. The distinctive markings usually soon disappear in alcohol and the species is then very difficult to determine.

We have examined nine specimens, 121 to 227 millimeters long, obtained at Calapan, Mindoro; Simara Island, Romblon Province; Dulag, Leyte; Cebu, Cebu; Zamboanga, Mindanao; and Tawitawi and Bungau Islands, Sulu Archipelago.

Living specimens in the Bureau of Science aquarium, obtained at Calapan, Mindoro, are golden with a dark brown band from nape across eye to lower jaw; behind this a bright, clear, pale yellow band across opercle to throat and a dark band behind it; ventrals whitish, the other fins all golden, anterior anal margin golden brown; small faint blue spots thickly sprinkled over sides of head and anterior two-thirds of body.

Bleeker states that the color is dark orange above, orange on sides posteriorly, belly pearly rose with orange spots; anterior portion of sides with about six blue undulate transverse bands, posteriorly with several blue longitudinal bands, partly broken, united before shoulder with the last transverse band; snout olivaceous rose, opercle orange and clouded rose; a wide deep brown band from nape over eye to lower jaw; the fin membranes partly, the rays orange; the membranes of spinous dorsal and anal cloudy orange.

This species occurs from Celebes and Flores eastward to the Pelew and Gilbert Islands. Seale obtained specimens, which he described as *Siganus zoniceps*, at Shortland, one of the Solomon Islands.

TEUTHIS VIRGATA (Cuvier and Valenciennes). Plate 4, fig. 3.

Amphacanthus virgatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 97; SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Leiden 2 (1839) 14, pl. 3, fig. 1.

Teuthis virgatus GÜNTHER, Cat. Fishes 3 (1861) 323.

Siganus virgatus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; JORDAN and EVERMANN, Bull. Bur. Fisheries 26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 247; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Cuyo name, *mandalada*.

Depth of the compressed, oblong body 1.9 to 2.2 in length, its dorsal and ventral profiles evenly and about equally arched from snout to caudal; head a trifle shorter than deep, 3.4 to 3.7 in length of body; the evenly convex interorbital more strongly arched in front, making the upper outline of snout straight and rather steep, its least width 2.8 to 3.4 in head; eye rounded, 2.7 to 3.5 in head; the moderate snout 1.2 to 1.8 times eye and 2 to 2.4 in head; maxillary extends almost below posterior nostril and is 1.6 to 1.9 in snout or 3.4 to 3.9 in head; width of preorbital behind angle of mouth 3.4 to 4.2 in head; in front of each eye two small rounded nostrils, the anterior having a low fleshy rim; the finely serrated angle of preopercle almost even with inferior and vertical edges; posterior margin of opercle has a flat, rather weak spine; least depth of caudal peduncle 3.3 to 3.7 in length of head.

Head unscaled above and on snout, orbital ring, jaws, chin, edges of preopercle, and lower three-fourths of opercle; all the fins excepting caudal are also naked; spinous dorsal highest along middle, the last spine 1.8 to 2.2 in head; the middle anal spines about as high as the last, which is contained 1.5 to 1.7 in head; the soft vertical fins very slightly angular, dorsal a little higher, 1.4 to 1.8 in head; caudal emarginate, upper lobe much longer than lower, its length greater than that of head, usually 2.7 to 3 times, rarely 3.3 to 3.5 times in total length; caudal 1.2 to 1.4 times the broad pectoral which is a little shorter than head and 1.8 to 2.2 in depth of body; ventral fin scarcely reaches origin of anal, 1.5 to 1.66 in head, 1.3 to 1.5 in pectoral; outer ventral spine nearly as long as longest ventral ray and much longer than inner spine which is about 2 to 2.4 in head and 1.6 to 2.2 in pectoral.

In the Bureau of Science aquarium are living specimens from Calapan, Mindoro, which are colored as follows: A wide red-

dish brown band extends diagonally forward from origin of dorsal through eye to below mouth, and a similar one of like color from base of fourth to sixth dorsal spines to base of pectoral; these bands are edged with bluish and the space between them is silvery white, as is the region in front of anterior band; color of trunk yellow on upper posterior portion, passing into silvery below and anteriorly immediately behind the posterior reddish brown band, and is overlaid with very light olive; spinous dorsal and entire anal clouded with brownish, soft dorsal yellow; a broad white crossband on caudal peduncle; caudal yellow with a white line on posterior margin, the other fins pale; several diagonal bluish lines on anterior portion of trunk and on each side of head, some of them on the reddish brown bands; bluish spots present also on each side of body and more numerous anteriorly above lateral line; top of head and interorbital crossed by several transverse blue lines.

Alcoholic specimens are yellowish brown or violet-brown, with deep brown transverse lines on forehead and nape; on upper portion of trunk are scattered bluish spots which become less numerous posteriorly; a wide deep brown band runs diagonally downward and forward from origin of dorsal through eye and below jaws to throat, where it joins its fellow, and a second one from sixth and seventh dorsal spines to base of pectoral, both bands edged with bluish; some bluish oblique streaks on snout; all the fins unmarked and lighter in color than body.

Of this species we have examined specimens ranging in length from 30 to 190 millimeters, from the following localities:

Balaoan, La Union, 1.
Bolinao, Pangasinan, 3.
Olongapo, Zambales, a ripe female, 159 millimeters long, collected April 7, 1921.
Monja Island, Corregidor, 2.
Calabanga, Camarines Sur, 1.
Puerto Galera, Mindoro, a ripe female, 190 millimeters long, taken in April, 1912.
Calapan, Mindoro, 35.
Bulalacao Bay, Mindoro, 1.

Masbate Island, 2 females in near-spawning condition, taken June 2, 1922.
Bantayan Island, 5.
Cebu, Cebu, 1.
Inabanga, Bohol, 1.
Dumaguete, Oriental Negros, 2.
Cuyo Island, 1.
Puerto Princesa, Palawan, 2.
Balabac Island, 2.
Samal Island and Zamboanga, Mindanao, 5.
Bungau, Sulu Archipelago, 2.

This fish has been recorded from the Philippines by Günther; from Panay Island by Jordan and Seale; from Cuyo by Jordan and Richardson; from Bacon, Sorsogon, by Evermann and Seale;

and from Zamboanga by Seale and Bean. It is very common around reefs in all parts of the Philippines.

It is known from the Andamans to the Malay Archipelago and ranges northward to the coast of China.

TEUTHIS DOLIATA (Cuvier). Plate 2, fig. 3.

Siganus doliatus CUVIER, Règne Anim. Guérin, Icon. Poiss. 4 (1830) pl. 36, fig. 1; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 359.

Amphacanthus doliatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 96; CUVIER, Règne Anim. Disciples' ed. Poiss. Atlas 8 (1836) pl. 71, fig. 1; KNER, Novara Reise, Fische (1865) 209.

Teuthis doliata GÜNTHER, Cat. Fishes 3 (1861) 323; Fische der Südsee 1 (1873) 90; PETERS, Monatsber. Akad. Wiss. Berlin (1876) 835.

Depth of the oblong appressed body 2.1 in length; head shorter than deep, 3.6 in length, upper profile rather conspicuously arched in front of eyes, giving a moderately steep and straight outline to snout; the slightly convex interorbital 3.3 in head and slightly narrower than eye, which is 2.9 in head; snout 2.2 in head and 1.8 times maxillary, which reaches nearly below posterior nostril; width of preorbital at angle of mouth 4.3 in head and twice in snout; 14 brown tridentate teeth on each side in both jaws, the central point of each tooth large, the lateral ones very small; the two nostrils in front of each eye simple rounded openings; angle of preopercle a little prolonged and finely serrated; orbital ring finely serrated in front; a flat weak spine at posterior edge of opercle; depth of caudal peduncle equal to least width of interorbital space.

Scales absent above and behind eyes, on snout, preorbital, lips, chin, edges of preopercle, and opercle; all the fins excepting caudal also naked; middle dorsal spines higher than the rest, the last one twice in head; the anal spines increase in height to the last which is 1.7 in head; both soft dorsal and anal angular and equal in height, their longest rays 1.5 in length of head; the moderately concave caudal a trifle longer than head; pectoral shorter than head and about twice in depth of body; ventral fin reaches nearly to origin of anal, its rays 1.6 in head and 1.3 in pectoral, its outer spine longer than the inner one, 1.7 in head, the inner spine 1.95 in head.

Color in alcohol dark brown dorsally, paling to creamy and very pale brown on sides of head and breast; ventral half of side pale olive buff; sides with more than twenty vertical bluish lines, many of them looped above and below, the anterior and posterior ones bent below and running longitudinally backward

below middle of side and along lower part of caudal peduncle; some of the lines on posterior half reticulated; dorsally the lines fade to dark brown; top of head and snout barred by transverse lines, side of head obscurely barred and reticulated.

Here described from the only specimen in the Bureau of Science collection, 141 millimeters long, collected at Puerto Princesa, Palawan. This fish, which is new to the Philippines, is known from the Moluccas, the New Hebrides, Santa Cruz, Pelew, Caroline, Fiji, and Society Islands.

TEUTHIS TETRAZONA (Bleeker).

Amphacanthus tetrazona BLEEKER, Nat. Tijd. Ned. Ind. 8 (1855) 441.

Teuthis tetrazona GÜNTHER, Cat. Fishes 3 (1861) 323.

Siganus tetrazonus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

The body is oblong, compressed, the height between the first dorsal spine and the anterior ventral spine about 3, between the 7th dorsal spine and the first anal spine about two and three fifths in its length, breadth 3 to $3\frac{1}{2}$ in its height; the head almost 4 in the body length, scarcely longer than high; the rostro-dorsal line concave on top of the snout, convex before the eyes; the diameter of the eye about $2\frac{1}{2}$ in the length of the head; the orbital bones denticulate; the interocular line is slightly convex; the snout is sharp, without the superior maxilla shorter than the eye; teeth on each side of the maxilla about 24, below the emarginate apex subtrilobate; the suborbital bone at the angle of the mouth shorter than the diameter of the eye; the opercle and preopercle scarcely or not striated; the scales are very small, hardly noticeable behind the shoulder girdle, the others uniform; the lateral line is of subcontiguous tubules, each tubule characterized by a toothless branch above; the first dorsal scarcely notched between the spinous and rayed part, the spines large, the 9th and 10th longer than the others, about $2\frac{1}{2}$ in the body height, the first shorter than the others; the soft dorsal a little lower than the spinous dorsal, obtusely rounded; the pectoral tip acutely rounded, about $5\frac{1}{2}$, the ventral about 7, the caudal a little notched, the lobes rounded, about $5\frac{1}{2}$ in the length of the body; the anal spines strong, the posterior ones longer than the others, the soft part convex and scarcely higher; the color of the body and fins beautiful yellow; the back with 4 pairs of transverse undulate dusky bands descending below the middle of the side, the anterior band about under the third dorsal spine, the second under the seventh and eighth dorsal spines, the third under the eleventh and twelfth dorsal spines, the fourth under the third and fourth dorsal rays. (Bleeker.)

The length given in the above measurements evidently includes the caudal fin. Jordan and Seale had 3 small specimens from Manila and 2 from Cavite, the largest 128 millimeters long. Their description follows, the caudal not included:

Head 3.5 in length; depth 2.1; eye 3.1 in head; snout 2.5. Color in spirits bluish white, with 4 broad cross-bands of dusky over back and down one side; base of caudal dusky; fins splotched with dusky.

The Bureau of Science collection contains ten immature specimens, 21 to 25 millimeters in length, collected by Alvin Seale at Zamboanga, Mindanao, and determined by him as *Siganus tetrazonus*. They are uniform brown except on the breast and belly, which are bright silver; the opercles also have a silvery sheen; some of them show the four dusky bands inclined diagonally forward, much as described by Bleeker, but most of them have only dusky spots along the base of the dorsal, the rest of the bands having faded.

Bleeker had one lone specimen, 64 lines (about 133 millimeters) long, from Manado, Celebes.

We doubt the validity of this species. It is probably a color phase of *T. concatenata*, as indicated in our remarks under that species.

TEUTHIS JAVUS Linnaeus. Plate 5, fig. 3.

Teuthis javus LINNÆUS, Syst. Nat. ed. 12 1 (1766) 507; GÜNTHER, Cat. Fishes 3 (1861) 315; MEYER, Ann., Soc. España Hist. Nat. 14 (1885) 22.

Amphacanthus javus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 86.

Siganus javus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271; FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922) 57.

The greatest depth of the compressed, ovate-oblong body is at origin of anal fin, 2.1 to 2.3 in length, back and abdomen evenly and equally arched from snout to caudal peduncle; length of head equals its depth, 3.6 to 4.2 in total length, upper profile steeply inclined, forming a straight or nearly straight line from origin of dorsal to tip of snout; interorbital space is moderately convex and has a central shallow groove which narrows anteriorly, its least width 2.9 to 3.3 in head; the rounded eye 2.7 to 3.5 in head, anterior edge of orbital ring serrated; the obtuse snout 2.4 to 2.6 in head and 1.4 to 1.6 in maxillary, which is contained 3.5 to 3.9 in head and extends posteriorly to below posterior nostril; width of preorbital at posterior end of maxillary 2.3 to 2.8 in length of snout or 5.6 to 7.2 in that of head; the two nostrils in front of each eye small, the anterior one rounded and having a fleshy flap behind; preopercle somewhat indistinctly serrated at its angle; opercle armed with a flat weak spine at its hind border; least depth of caudal peduncle 3.5 to 4 in length of head.

Head scaled on cheek, uppermost angle of preopercle behind eye, and upper part of opercle, the remaining portions naked; fourth dorsal spine highest, equal to head without snout, the last one 2.1 to 2.9 in head, equal to or a little more or less than snout; third and fourth anal spines higher than the rest, seventh or last spine 1.7 to 2.1 in head; both soft dorsal and anal rounded, the former slightly the higher, its longest rays 1.5 to 1.8 in head; the lunate caudal longer than head, 3.1 to 3.7 in length, its lobes equal; pectoral shorter than head and 1.4 times ventral, which reaches a little more than halfway to anal; outer spine of ventral 1.75 to 1.9 in head, longer than inner one which is contained 1.8 to 2.4 in pectoral.

Ground color of living specimens in the Bureau of Science aquarium, collected at Calapan, Mindoro, is greenish, with large, more or less rounded bluish white spots along back, these becoming elongated on sides, confluent and forming longitudinal streaks and stripes on abdomen, narrower than the interspaces; caudal fin dusky with darker edges, the other fins light orange; ventral spines white.

In alcohol the ground color is brown, becoming much lighter on abdomen; on head and back many bluish white rounded spots, becoming oblong on middle of sides, elongated, confluent, and forming longitudinal lines on abdomen; vertical fins and caudal uniformly brownish violet; pectoral and ventrals yellowish; in one specimen all the fins are blackish.

We have examined 21 specimens in the Bureau of Science collection, ranging from 33 to 280 millimeters in length, from the following localities: Olongapo, Zambales; Malabon, Rizal Province; Manila; San Miguel Bay and Calabanga, Camarines Sur; Pinamalayan, Mindoro; Catbalogan, Samar; Estancia, Panay; Dulag, Leyte; Dumaguete, Oriental Negros; Balabac Island; and Sandakan, Borneo.

Meyer collected specimens from Manila Bay and at Cebu; Jordan and Seale had it from Cavite; Evermann and Seale from Bulan, Sorsogon; Jordan and Richardson from Manila and Cebu; and Fowler and Bean from Cebu.

This well-defined species occurs from Ceylon to Hobson Bay, near Melbourne, Australia.

TEUTHIS LINEATA (Cuvier and Valenciennes).

Amphacanthus lineatus CUVIER and VALENCIENNES, Hist. Nat. Poiss.
10 (1835) 95, pl. 286.

Teuthis lineata GÜNTHER, Cat. Fishes 3 (1861) 322.

Siganus lineatus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35.

The height of the body is two and a half times in the length, and the head four times and a half. The spines are of moderate height, and the tail feebly cut into a crescent; the spines are very strong and striated. In alcohol it appears brown, but clear towards the belly, with longitudinal lines little evident and dark brown spots on the tail. Three or four oblique bluish lines show under the eye and on the jaw. In the fresh state, according to the naturalists who found it and whose description we cite, it is of a bluish white. The tawny longitudinal lines traverse its length to the number of 9 or 10, forming upon the back isles and knots, interrupted on the belly and reduced to dots near the anal; upon the head the lines are alternately reddish and blue, descending obliquely forward. The spinous part of the dorsal and anal is yellowish; the soft part and likewise the caudal are purplish brown; reddish or brown spots are sprinkled upon the end of the caudal peduncle, the caudal, and the soft dorsal and anal. The ventrals and pectorals are yellowish. The back has a large yellow spot under the soft dorsal, sprinkled with small black dots and surrounded by a red circle. (*Valenciennes*.)

The length given in the above measurements evidently includes the caudal. According to the figure the depth is twice in the length without the caudal, the head almost 4 times. Jordan and Seale had a specimen, about 145 millimeters long, from Manila; their description is as follows:

Head 3.75 in length; depth 2; eye 3 in head. Color in spirits bluish gray with brown dots or lines, the lines on upper part of body usually surrounding light bluish spots, some specimens (not all) showing a yellowish blotch at base of soft dorsal, and corresponding in every respect to the figure of Cuvier and Valenciennes (*Hist. Nat. Poiss.*, plate 286); belly yellowish white; fins with grayish wash. One specimen from Manila, length 5.75 inches.

While there is a discrepancy in their account, it is evident that they had one specimen of *T. lineata*. We have seen no specimens of this species, which is readily recognized by the conspicuous coloration of the spot under the soft dorsal, and the lines on the sides of the body. Except for the Manila specimens, it is only known from Vanicolo, one of the Santa Cruz islands, where it is common, and from New Guinea.

TEUTHIS STRIOLATA Günther. Plate 5, fig. 2.

Teuthis striolata GÜNTHER, Cat. Fishes 3 (1861) 319; Fische der Südsee 1 (1873) 89, text only.

Siganus striolatus SEALE, Occ. Papers Bishop Mus. 4 (1906) 69.

Amphacanthus striolatus WEBER, Fische Siboga Exp. (1913) 329.

Siganus marmoratus JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 35; ? JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 271.

Depth of the compressed, rather elongate body 2.5 to 3 in length, both dorsal and ventral outlines evenly and about equally curved from snout to caudal; the head is very slightly arched above and has a somewhat conspicuous swelling in front of eyes, causing the upper profile of snout to be steep; length of head equal to its height, 3.7 to 4.1 in total length; interorbital space almost flat, its least width 3.3 to 3.8 in head; the rounded eye slightly shorter than snout, 2.6 to 2.9 in head, edge of orbital ring entire; snout broad posteriorly and rather short, 2.4 to 2.6 in head; maxillary, which extends back a little behind a vertical from posterior nostril, shorter than snout, 2.4 to 2.9 times width of preorbital at angle of mouth; the two nostrils in front of each eye rounded, the anterior one slightly the smaller and having a very high, rather wide fleshy flap behind; angle of preopercle has a few indistinct serræ at its edge and forms a very shallow notch with the vertical limb; a flat, weak spine fairly conspicuous on posterior edge of opercle; least depth of caudal peduncle 3.8 to 4.6 in head.

Cheek, uppermost portions of opercle, and preopercle covered with scales, the rest of head naked; caudal fin thickly scaled near base, the other fins naked; dorsal spines of moderate strength, the middle ones the highest, the last spine 2.6 to 3.1 in head; middle anal spines the highest, the last one 2 to 2.5 in head; both soft dorsal and anal rounded, the former a little higher and contained 1.6 to 1.7 in head; the slightly emarginate caudal shorter than head, 1.5 to 1.7 in depth of body, 1.09 to 1.21 in head; the broad pectoral still shorter than caudal fin, 1.2 to 1.38 in head and 1.2 to 1.5 times ventral fin, which reaches about halfway between anus and origin of anal; outer ventral spine 1.63 to 1.9 in head, longer than inner one, which is 1.4 to 1.7 in pectoral, 1.8 to 2.1 in head.

Living specimens in the Bureau of Science aquarium, collected at Calapan, Mindoro, are greenish on upper half of body, whitish on lower half, and are covered all over with brilliant bluish vermiculated lines; there are transverse bluish lines on caudal peduncle; dorsal and anal yellowish, their rayed portions spotted with brownish; caudal fin mottled with yellowish and dusky, its upper, lower, and hind margins darker; both pectoral and ventrals whitish.

Color in alcohol brownish to rich reddish or blackish dark brown, paler to bluish ventrally, covered with many narrow vermiculated lines which often anastomose to form reticulations, especially dorsally, and become sinuously longitudinal along

sides, usually more or less vertical below soft dorsal and on caudal peduncle; a dark crossband on base of caudal peduncle, bounded by a narrow clear crossband on each side; dorsal spines vaguely spotted, spinous dorsal and anal clouded with brown or with a vague longitudinal band of brown or violet-brown; soft dorsal and anal crossbanded by alternate rows of brownish or dark brown and pale spots; caudal barred by four or five irregular dark crossbands, distinct on upper and lower margins but usually vague within; pectoral yellowish to almost colorless; only one or two specimens have the fins unspotted and all show bars on caudal; some have a very dark crossbar on base of caudal fin.

We have examined 41 specimens, 36 to 155 millimeters in length, from the following localities:

Luna, La Union, 4.	Bantayan Island, 1.
Nalvo, La Union, 2.	Tacloban, Leyte 1.
Paraair, La Union, 2.	Canigaran, Palawan, 6.
Bolinao, Pangasinan, 5.	Dumaguete, Oriental Negros, 1.
Calapan, Mindoro, 9.	Zamboanga, 3.
Pinamalayan, Mindoro, 5.	Guam, 2.

Jordan and Seale had a specimen from Manila which was evidently this species, and Jordan and Richardson had one from Calayan which was probably *Siganus striolatus*. It has been recorded from the New Hebrides, Solomon, Samoa, Friendly, and Society Islands by Günther, and from the Society Islands by Seale; Weber obtained it at Obi Major, one of the Moluccas, and Biarue, one of the Sangir group.

From *T. marmorata*, with which it has been confused, it may be distinguished by the narrow vermiculated lines, which are broader than the interspaces in *T. marmorata*, and by the presence of the characteristic crossbars on the caudal peduncle and caudal fin.

TEUTHIS VERMICULATA (Cuvier and Valenciennes). Plate 3, fig. 1.

Amphacanthus vermiculatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 10 (1835) 92; BLEEKER, Verh. Bat. Gen. 23 (1850) Teuthieden, 11; WEBER, Fische Siboga Exp. (1913) 326.

Teuthis vermiculata GÜNTHER, Cat. Fishes 3 (1861) 317; DAY, Fishes of India (1878) 166, pl. 40, fig. 1.

Siganus vermiculatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 98; SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 248; SEALE, Philip. Journ. Sci. § D 5 (1910) 283.

The compressed oblong body rather deep, its depth 1.9 to 2 in length, dorsal and ventral profiles evenly and equally arched;

head as deep as long, 3.3 to 3.7 in length, 1.7 to 2 in greatest depth of body, its upper outline slightly arched in front of eyes; width of the slightly convex interorbital 2.8 to 3.2 in head; the rounded eye 1.3 to 1.7 in snout, which is 2 to 2.3 in head; maxillary extends almost below posterior nostril, 3.3 to 3.6 in head; width of preorbital at angle of mouth less than length of maxillary and about twice in snout; two small nostrils present before each eye, the anterior one rounded and the other a crescentlike slit; preopercle finely serrated at its angle, which is slightly produced behind; a flat hidden spine present at posterior edge of opercle; front edge of orbital ring with fine but rather strong teeth; least depth of caudal peduncle 3.2 to 3.3 in length of head.

Head naked above and behind eyes, on snout, preorbital, lips, chin, limbs of preopercle, and opercle; caudal fin scaly, especially near base, all the other fins naked; dorsal spines rather strong, the last one highest, 1.7 to 1.8 in head; anal spines evenly graduated to the last which is the highest, 1.4 to 1.5 in head; the soft vertical fins rounded and equal in height, the longest rays 1.2 to 1.3 in head; caudal fin slightly emarginate, the lobes equally forked, 3.5 to 4.1 in length of body; pectoral fin less than half the greatest depth of body, 1.2 to 1.3 in head, and much longer than ventral which scarcely reaches anal fin; outer ventral spine longer than inner one, 1.5 to 1.6 in pectoral, 1.75 to 2 in head.

In alcohol the ground color is brown, nearly white on belly; the entire head and trunk covered with vermiculated bluish white lines, running longitudinally; vertical fins brownish violet with darker spots near their base; caudal fin spotted all over with violet-brown; pectoral uniformly yellowish and ventrals slightly washed with violet.

Here described from forty-six specimens, 27 to 164 millimeters long, collected at the following places: Burgos, Ilocos Norte; Luna, La Union; Agno River, Pangasinan; Biga-a River and Legaspi, Albay; Jordan, Guimaras Island; Cabalian, Leyte; Loay, Bohol; and Zamboanga and Davao, Mindanao. The Bureau of Science collection also has a fine large specimen, 211 millimeters long, from Sandakan, Borneo.

Günther recorded this species from the "Philippine Islands;" Evermann and Seale listed it from San Fabian, Pangasinan, Bacon, Sorsogon, Zamboanga, and "the Philippines;" Seale and Bean had specimens from Zamboanga.

Elsewhere it is known from Isle de France throughout the East Indies to New Guinea, and eastward to the Solomon and Admiralty Islands. It attains a length of at least 290 millimeters.

Genus *LO* Seale

Lo SEALE, Occ. Papers Bishop Mus. 4 (1906) 71.

From *Siganus*, to which *Lo* is very close, indeed, the latter can be distinguished at a glance by the slender, elongate, laterally flattened, tubulate snout which forms a short beak, and by the depressed anterior profile, which impart an aspect altogether different from that of any other siganid, all the rest having a more or less convex profile to the head. The shape of the body is also different, being more rectangular. Pyloric cæca 3 + 2, one on each side very small. In other respects it does not diverge materially from *Siganus*. Both of the species of *Lo* are of singular beauty.

Key to the species of *Lo*.

- α^1 . A large blackish lateral spot below base of posterior spines and anterior rays of dorsal..... *L. unimaculatus*.
 α^2 . No large dark lateral blotch on body..... *L. vulpinus*.

LO UNIMACULATUS Evermann and Seale. Plate 3, fig. 2.

Lo unimaculatus EVERMANN and SEALE, Bull. Bur. Fisheries 26 (1907) 99, fig. 19.

Body compressed and moderately elongate with upper and lower profiles nearly parallel from origin of dorsal to origin of rayed dorsal, its greatest depth 2.1 in length; head produced and longer than deep, its length 3.1 to 3.2 times in that of body and its upper outline a little concave; the unevenly and slightly convex interorbital very slightly wider than eye which is contained 3.9 to 4 in head; the elongate tubular beaklike snout 1.8 in head and 2.7 to 2.8 times maxillary which is about 5 in head; mouth small, terminal, with about 12 teeth on each side of both jaws, those of upper jaw brown-tipped, those of lower jaw smaller and plain white; preorbital 1.3 in snout or 2.3 to 2.4 in head at its greatest depth; two very small nostrils in front of each eye, the anterior one in a low tube and the other a simple opening; a rather indistinct notch above angle of opercle, which is minutely serrated, as is the inferior edge; preopercle unarmed; least depth of caudal peduncle less than half the length of snout, 3.9 to 4.5 in head; head scaled on cheek

and on upper angles of opercle and preopercle; trunk and caudal peduncle completely covered with minute cycloid scales; caudal fin scaly, the other fins naked; middle dorsal spines highest, the last 2 to 2.2 in head; last anal spine highest, about as long as snout, 1.8 to 2 in head; the soft portions of dorsal and anal slightly angular, the former slightly the higher and 1.5 to 1.7 in head; the moderately forked caudal shorter than head, 3.6 to 4.3 in length of body; pectoral about as long as from tip of snout to posterior margin of pupil, 1.27 to 1.37 in head, or 4.1 to 4.4 in length; ventral extends to base of first anal spine, 1.5 to 1.6 in head; last ray about as long as outer spine, which is 1.3 to 1.4 times inner one.

Alcoholic specimens mottled with brownish; a broad blackish band extends from origin of dorsal through eye to mouth, uniting with the other on opposite side at both ends, inclosing a paler longitudinal area on top of head; breast blackish, this color extending to above base of pectoral and to outer spine and ray of ventral fin; a large blackish blotch of circular or irregular shape on lateral line below posterior spines and anterior rays of dorsal; dorsal, anal, and caudal yellowish white, or dorsal spines brownish yellow anteriorly, or first dorsal spine may be blackish; a dusky line on both sides of each anal spine; first pectoral ray blackish, the rest of the fin very pale yellowish.

We have 4 specimens, 138 to 174.5 millimeters in length; one from Elefante Island, Marinduque Province, two from Tagapula Island, Samar Province, and one from Cebu, Cebu.

Known heretofore only from the type specimen described by Evermann and Seale from Bacon, Sorsogon.

This species is distinguished at a glance from *Lo vulpinus* (Schlegel and Müller) by the presence of the large blackish blotch far back on lateral line.

LO VULPINUS (Schlegel and Müller). Plate 6.

Amphacanthus vulpinus SCHLEGEL and MÜLLER, Verh. Nat. Gesch. Ned., Leiden 2 (1844) 12; SCHLEGEL, Bijdr. Dierk. 1^e (1852) 38, fig. 1; WEBER, Fische Siboga Exp. (1913) 330.

Teuthis vulpinus GÜNTHER, Cat. Fishes 3 (1861) 324.

Teuthis vulpina GÜNTHER, Fische der Südsee 1 (1873) 91.

Lo vulpinus SEALE, Occ. Papers Bishop Mus. 4 (1906) 71, fig. 19;

JORDAN and SEALE, Bull. Bur. Fisheries 25 (1906) 361.

Siganus vulpinus FOWLER and BEAN, Proc. U. S. Nat. Mus. 62 (1922)

59.

The oblong compressed body moderately elongate, its depth 2.2 to 2.4 in length, dorsal and ventral outlines nearly parallel

from nuchal region to first dorsal ray; head produced anteriorly, much longer than deep, its length 3.1 to 3.3 times in that of head and body together, its upper profile concave, rising above eye in a thin trenchant ridge; interorbital space nearly flat and with a conspicuous protuberance on front and upper angle of eye, its width 3.3 to 3.7 in head; diameter of the rounded eye 3.5 to 3.9 in head or nearly twice in the long produced snout, which is 1.8 to 1.9 in length of head; maxillary shorter than eye, 4.6 to 5.2 times in head; preorbital 1.2 to 1.6 in snout or 2.3 to 2.9 in head; two very small nostrils in front of each eye, the anterior one in a low fleshy tube and the other a simple rounded opening closer to the former than to anterior edge of eye; a very shallow notch above angle of preopercle, which is finely serrated as is also its inferior margin; opercle unarmed behind; least depth of caudal peduncle 3.9 to 4.1 in head.

Head naked except on cheek, and on uppermost portions of opercle and preopercle; trunk and caudal peduncle completely covered with tiny scales; all the fins naked except caudal, upon which minute scales extend for half its length; middle dorsal spines equal to or a little higher than the last one, which is 1.8 to 2 in head and nearly as long as snout; last anal spine highest, higher than last dorsal spine, 1.7 to 1.9 in head; soft dorsal and anal pointed behind, the former slightly higher, 1.6 to 1.8 in head; caudal fin moderately forked and shorter than head, 1.1 to 1.4 in head and 3.6 to 4.4 in length, its lobes equally produced; pectoral a trifle shorter than caudal fin, 1.2 to 1.4 in head; ventral fin reaches origin of anal, its outer spine much longer than the inner one and contained 1.5 to 1.6 in head.

Alcoholic specimens more or less whitish, yellowish, or mottled brown, to largely blackish brown, upper part usually darker, sometimes umber or blackish; posterior third usually but not always paler; from origin of dorsal a broad black or dark brown band extends diagonally downward and forward over eye to end of snout, including upper and lower lips, joining its fellow on nape and chin, and leaving a paler median stripe from nape to base of upper lip; behind this band is a broader diagonal pearly white or brownish band, profusely sprinkled with reddish brown dots, covering the remainder of head below and behind eye, and extending across anterior extremity of breast; breast black to dark brown, the color extending above base of pectoral behind and into gill opening, and posteriorly to ventrals; dorsal, anal, and caudal vary from pale yellowish white to brown; upper

ray of pectoral brown to blackish, the rest of the fin whitish to brown; ventral spines blackish or brown, the rays brownish.

The Bureau of Science collection has nine specimens, from 149 to 180 millimeters in length, from the following localities: Calapan and Bulalacao Bay, Mindoro; Sibuyan; Bennett Island, Masbate; and Zamboanga, Mindanao. The only previous record from the Philippines is that by Fowler and Bean, who had four specimens from Zamboanga.

In life this is a fish of great beauty and stateliness. A specimen kept for a year or two in the Bureau of Science aquarium was one of the most attractive on exhibition. The prevailing color was deep orange on the posterior half, the caudal and the vertical fins; the anterior half was banded as described above, but the colors were lustrous and in strong contrast.

This very handsome siganid has been recorded from Celebes, Ternate, Amboina, New Guinea, and the Solomon and Pelew Islands. According to Weber, it does not range west of Celebes. As it is unknown in Polynesia, it seems to have a restricted range.

SUMMARY OF THE PHILIPPINE SIGANIDÆ

SIGANIDÆ (TEUTHIDIDÆ)

1. Genus *TEUTHIS* Linnæus

1. *fuscescens* (Houttuyn).
2. *concatenata* (Cuvier and Valenciennes).
3. *corallina* (Cuvier and Valenciennes).
4. *rostrata* (Cuvier and Valenciennes).
5. *hexagonata* (Bleeker).
6. *oramin* (Bloch and Schneider).
7. *sutor* (Cuvier and Valenciennes).
8. *puella* (Schlegel).
9. *virgata* (Cuvier and Valenciennes).
10. *doliata* (Cuvier).
11. *tetrazona* (Bleeker).
12. *javus* Linnæus.
13. *lineata* (Cuvier and Valenciennes).
14. *striolata* Günther.
15. *vermiculata* (Cuvier and Valenciennes).

2. Genus *LO* Seale

16. *unimaculatus* Evermann and Seale.
17. *vulpinus* (Schlegel and Müller).

ILLUSTRATIONS

PLATE 1

- FIG. 1. *Teuthis fuscescens* (Houttuyn). (Drawing by A. L. Canlas.)
2. *Teuthis corallina* (Cuvier and Valenciennes). (Drawing by José L. Nievera.)
3. *Teuthis rostrata* (Cuvier and Valenciennes). (Drawing by Pablo Bravo.)

PLATE 2

[Drawings by Pablo Bravo.]

- FIG. 1. *Teuthis hexagonata* (Bleeker).
2. *Teuthis sutor* (Cuvier and Valenciennes).
3. *Teuthis doliata* (Cuvier).

PLATE 3

[Drawings by A. L. Canlas.]

- FIG. 1. *Teuthis vermiculata* (Cuvier and Valenciennes).
2. *Lo unimaculatus* Evermann and Seale.

PLATE 4

[Drawings by A. L. Canlas.]

- FIG. 1. *Teuthis concatenata* (Cuvier and Valenciennes).
2. *Teuthis puella* (Schlegel).
3. *Teuthis virgata* (Cuvier and Valenciennes).

PLATE 5

[Drawings by A. L. Canlas.]

- FIG. 1. *Teuthis oramin* (Bloch and Schneider).
2. *Teuthis striolata* Günther.
3. *Teuthis javus* Linnæus.

PLATE 6

- Lo vulpinus* (Schlegel and Müller.) Drawing by A. L. Canlas.

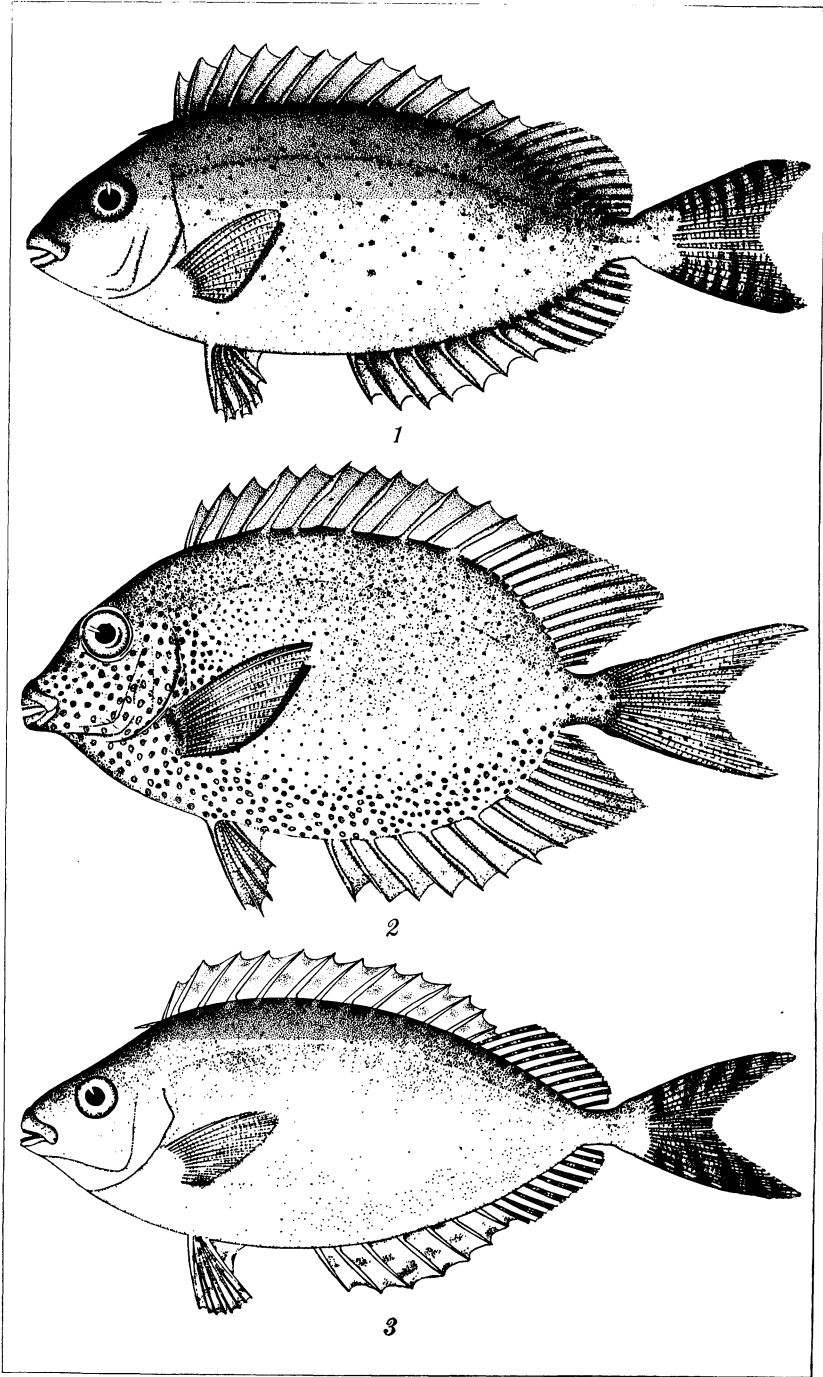


PLATE 1.

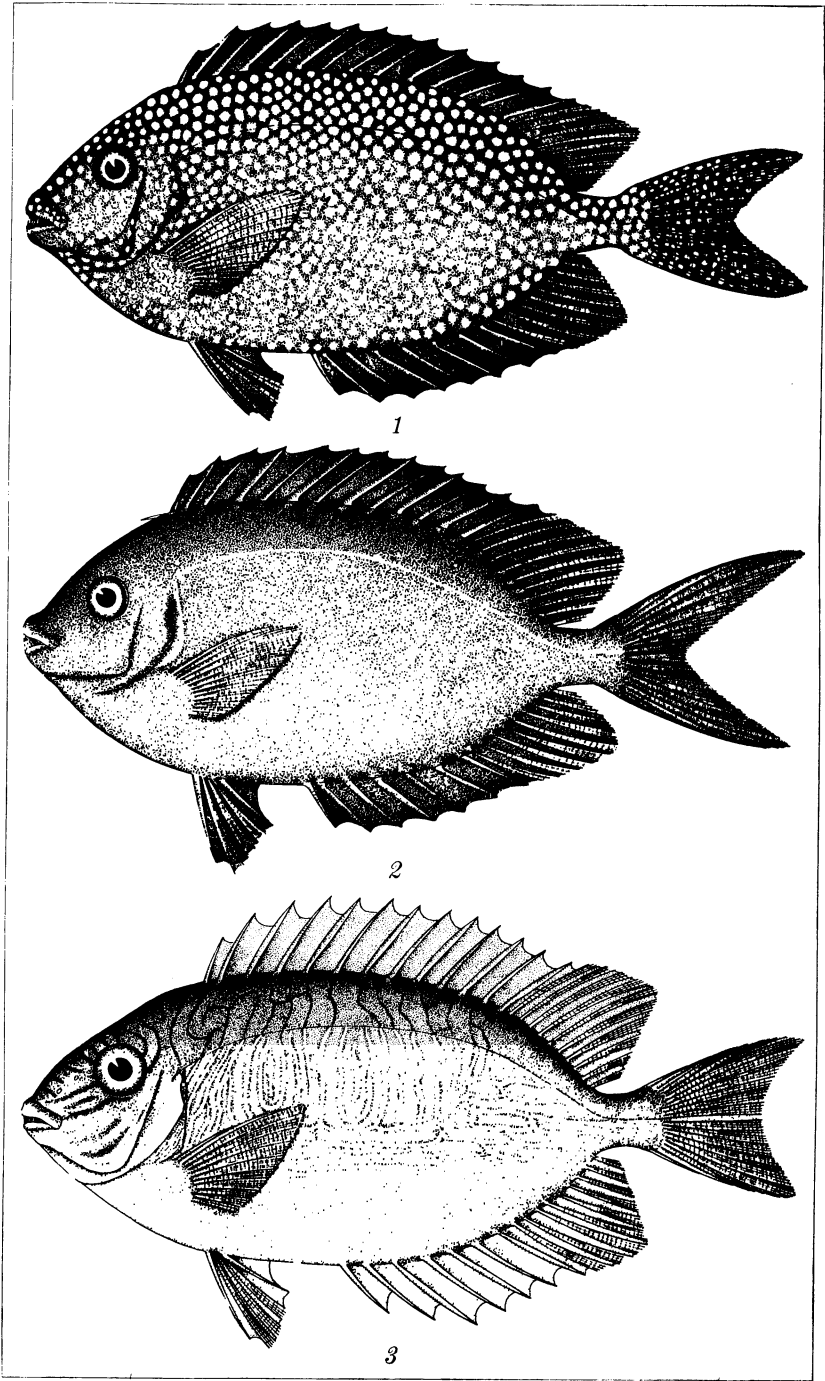
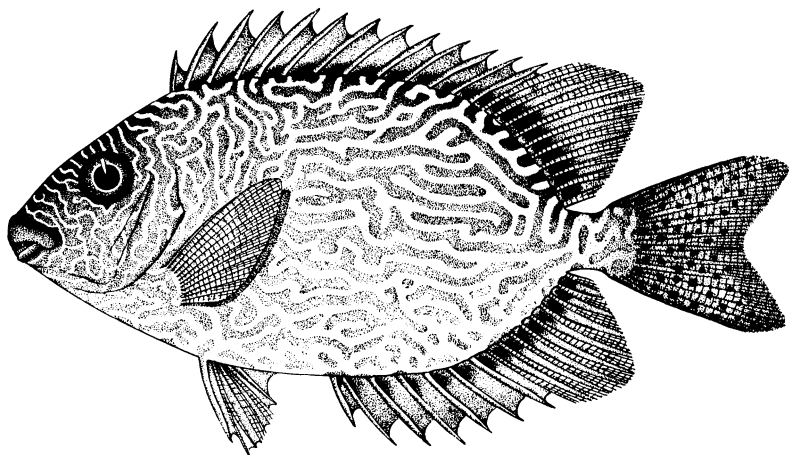
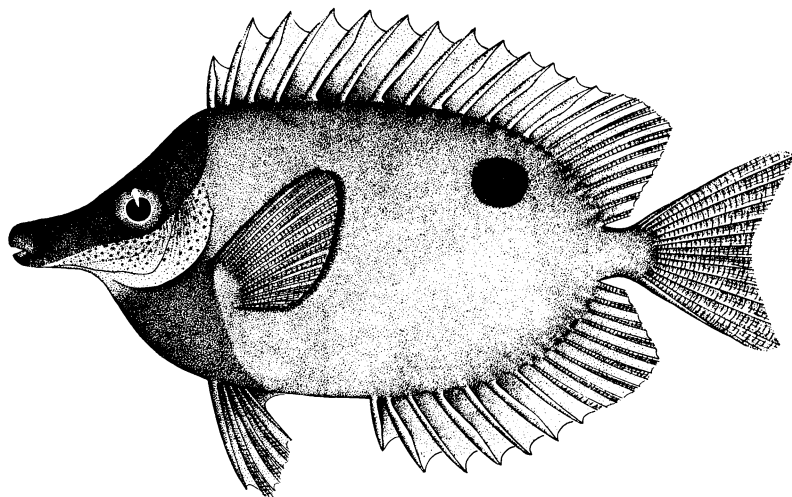


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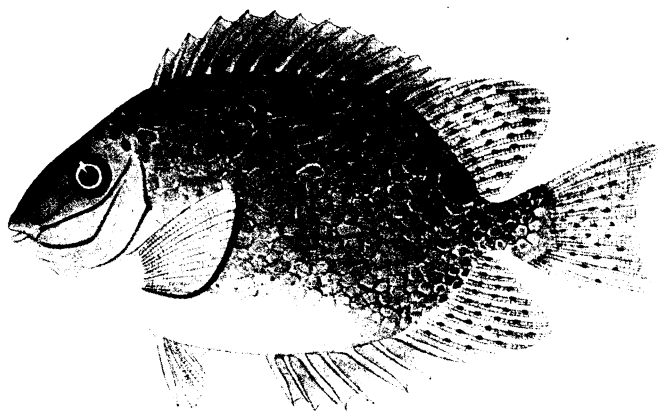


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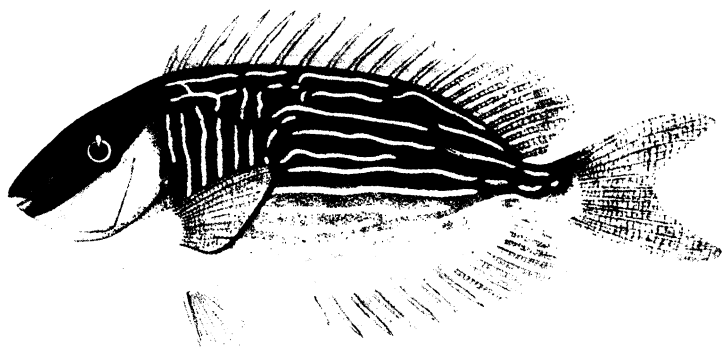


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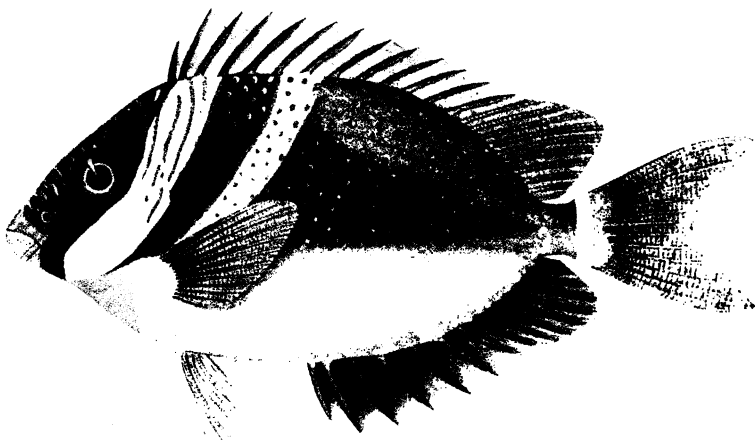




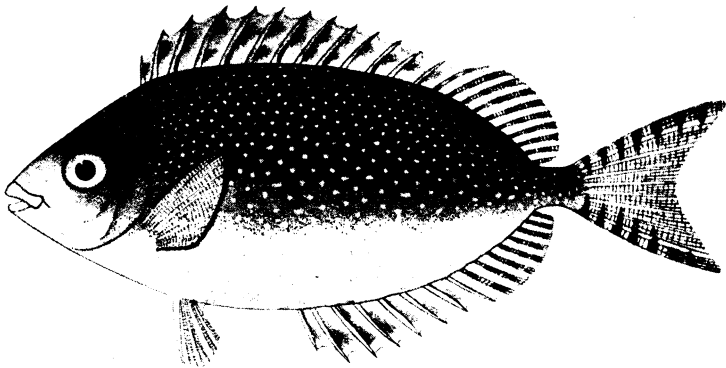
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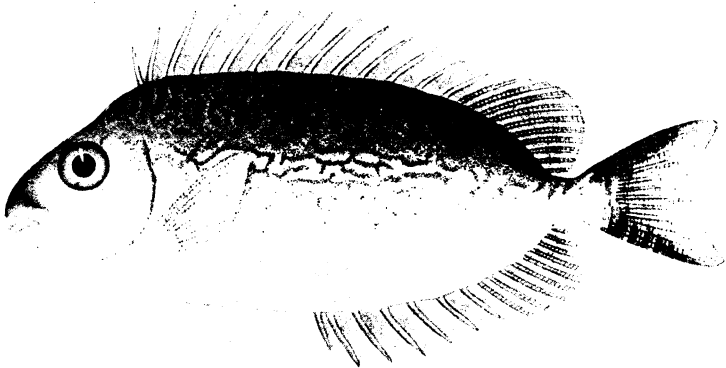
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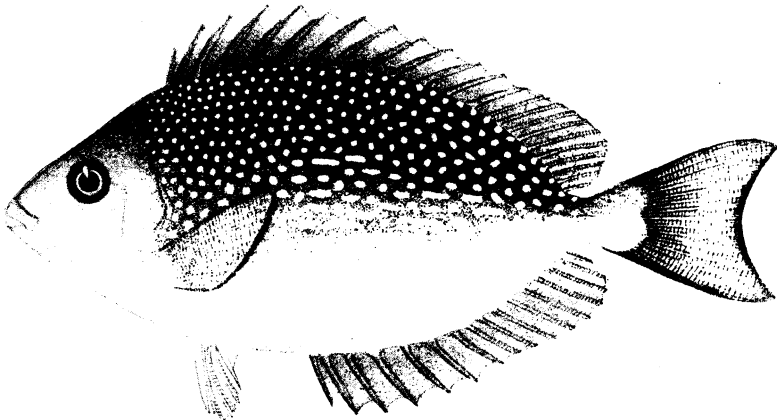
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PLATE 5.

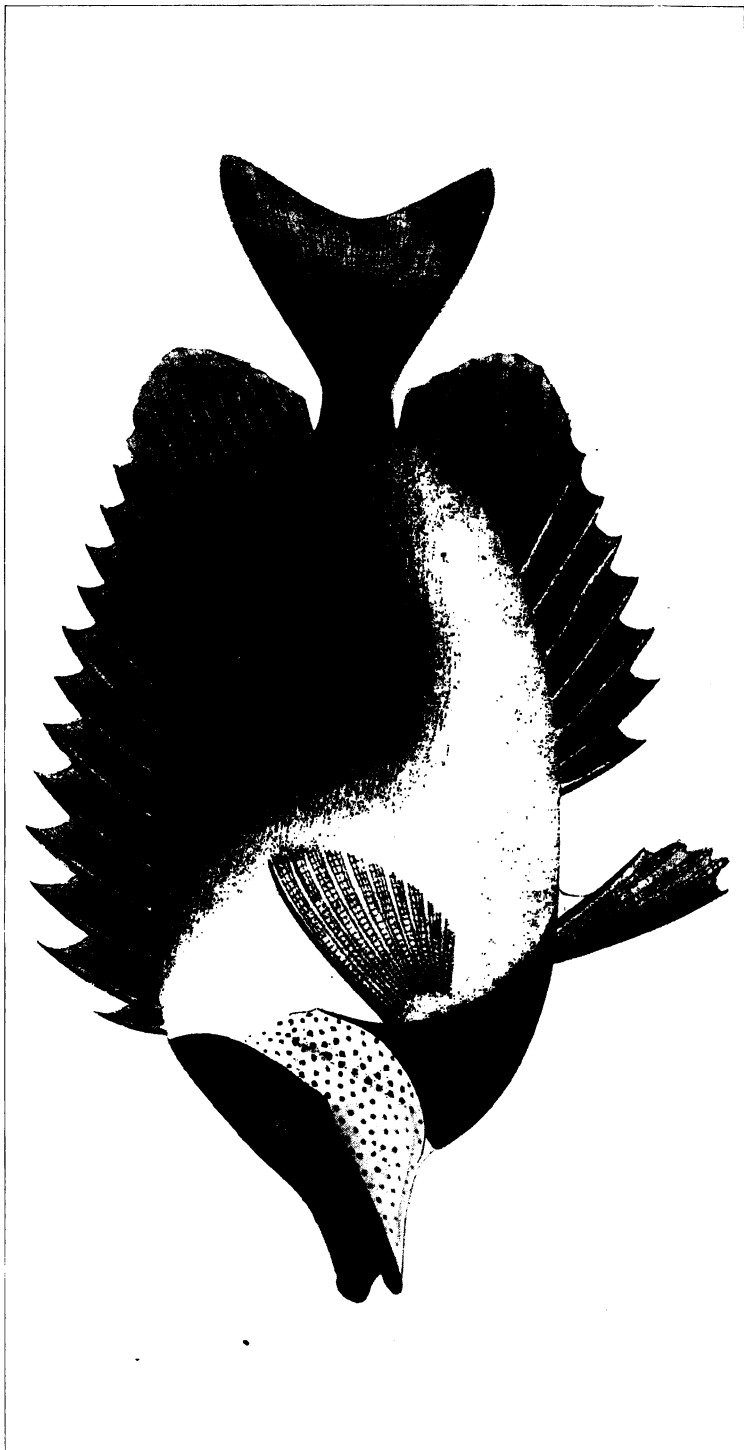


PLATE 6. *LO VULPINUS* (SCHLEGEL AND MÜLLER).

STEM AND LEAF STRUCTURE OF TINOSPORA RUMPHII BOERLAGE AND TINOSPORA RETICULATA MIERS

By JOSÉ K. SANTOS

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SEVEN PLATES

Much has been written and published in various works concerning the anatomical features of the Menispermaceæ. The subject, however, has by no means been exhausted, for the anatomical structure of this family in general is very characteristic in every species. Any further anatomical investigation, therefore, concerning the stems and leaves of this important family will be of considerable interest, notwithstanding the fact that valuable anatomical studies on a number of its species have been made in the past. Since *Tinospora rumphii* Boerlage and *T. reticulata* Miers afford excellent material for anatomical investigation, and because of the medicinal property reputed by the Filipinos to be possessed by one of the two species, which has a bitter taste, the writer undertook this piece of work in order to find the basis for differentiating the two plants.

Tinospora rumphii Boerlage and *T. reticulata* Miers are both commonly known as *makabuhay*, and sometimes the latter is called *makabuhay lalaki*. They are dioecious vines with perennial stems covered with prominent tubercles, twining around tall trees and sending out roots many meters in length which descend like cords to the ground. They are widely distributed throughout the Philippines and *T. rumphii* Boerlage is sometimes cultivated because of its very bitter characteristic. According to Merrill,⁽⁵⁾ *T. rumphii* was perhaps introduced from Malaya, while *T. reticulata* is endemic.

Merrill⁽⁶⁾ describes *Tinospora reticulata* Miers as a plant that possesses a very bitter characteristic. On the other hand, in a later work⁽⁷⁾ he states that—

The name *makabuhay* is universally applied in the Philippines to the two forms of *Tinospora*, but properly to the one with broad, deeply cordate leaves that has a very bitter principle in its stems.

which is the form characterized by Boerlage as *Tinospora rumphii*. Besides, Merrill, in a still later publication,(8) gives the same name, *T. rumphii*, to the plant exhibiting the same characteristic.

In India the species *Tinospora cordifolia* Miers is used and classified as a standard drug in the Indian Pharmacopœia. This plant is frequently substituted by *Tinospora crispa* Miers and by allied species, also found in the Indo-Malayan region. In view of the similarity between *T. crispa* and the bitter makabuhay from the Philippines, Tavera,(10) in describing the latter, applied the name *Tinospora crispa* Miers, which plant the writer believes is not found in the Philippines.

The bitter makabuhay has, on account of its economic value, long occupied a prominent place in chemical research, especially among plant chemists and pharmaceutical chemists, to whom the question is naturally an all-important one.

Bacon(1) and Feliciano,(2) working on the chemical composition of the bitter makabuhay, both reported their results under the name *Tinospora reticulata* Miers. Marañon,(4) on the other hand, recently conducted a very critical chemical investigation on the same bitter makabuhay and successfully isolated its bitter principle, and reported his results under *Tinospora rumphii* Boerlage.

Solereder,(9) in reviewing the work done on the anatomical features of the Menispermaceæ, indicates that in all the members of this family are observed the presence of broad primary medullary rays which separate the vascular bundles of the axis from one another; the undulated composite and continuous sclerenchymatous ring in the pericycle; the elongated secretory cells in the axis and in the petiole in certain members of the order; and the small crystals of calcium oxalate which are sometimes large, solitary, or clustered. Some of the prominent workers cited by him are Nageli, De Bary, Vesque, Schenck, Volken, Solereder, Haberlandt, and others. Unfortunately, most of their publications are not available.

MATERIAL AND METHODS

Tinospora rumphii Boerlage and *Tinospora reticulata* Miers, the plants that furnished the materials for this investigation, were collected from Antipolo, Rizal Province, Luzon, during the summer of 1925, and planted in the botanical garden in the University of the Philippines. Additional material for the study

of the bitter makabuhay (*Tinospora rumphii* Boerlage) was bought from a retail store in Binondo, Manila.

These two species of makabuhay were grown in the botanical garden side by side, and during the preparation of this paper the external morphological characters of the stems were carefully observed, and those of one species were compared with those of the other. The taste of the sap of their stems and leaves was tested.

Several cross and median longitudinal sections, from 20 to 35 microns thick, were used. Some of the sections were stained with safranin and contrasted with Delafield hæmatoxylin and mounted in balsam, while the other sections were simply examined and mounted in water and in dilute glycerine. For the examination of the individual shape and characteristics of the cells, Schulze's maceration process, as indicated by Greenish,⁽³⁾ was employed.

TINOSPORA RUMPHII BOERLAGE

THE STEM

The young fresh stems of *Tinospora rumphii* Boerlage are light green, succulent, smooth, and sometimes with minute elongated elevations which correspond to young lenticels arranged parallel to the axis. They bear broadly ovate and deeply cordate, alternate leaves (Plate 1, fig. 1). When the young stems are cut, they exude a clear, mucilaginous juice which has a very bitter taste. This bitter characteristic is also observed when the leaves are crushed between the fingers.

The adult stems, however, have a dark green or greenish brown color and succulent bark covered with numerous and prominent protuberances, at the tip of which the lenticels are found. They are invested with a very thin cork which peels off in flakes, and they are leafless. When bent they are more or less flexible, and when cut they exude abundant, somewhat milky or turbid, mucilaginous juice which has a very bitter taste. When dry they shrink very much and the bark separates from the wood and turns dull brown. The odor is not at all peculiar.

The drug of makabuhay sold in the market is always that of *Tinospora rumphii* Boerlage. This adult stem is cut to about 1.5 meters in length and wound up as indicated in Plate 1, fig. 2. It is usually obtained from the store in a more or less fresh condition. This is perhaps due to the fact that the makabuhay stem can stand long keeping without drying. The old stem

bought from the retail store at Binondo, after having been kept for about two months in the laboratory, has shrunk but slightly and sent out a slender root about 1 m long and about 1.2 mm in diameter. When planted, it developed new shoots and leaves.

Structure of the stem.—A thin transverse section from a young stem reveals that it is of the ordinary dicotyledonous type. It is more or less circular in outline and with slightly wavy margin and one or two glandular hairs. These glandular hairs are of multicellular type, uniseriate, and with somewhat rounded terminal cells. The epidermis consists of a single layer of colorless rectangular cells containing usually a large number of monoclinic and prismatic calcium oxalate crystals, as shown in Plate 1, fig. 5. In the surface preparation, these crystals appear as indicated in Plate 2, fig. 7. The cortex is thin and is composed of three or four layers of collenchyma cells and from six to eight layers of parenchyma cells, both containing chloroplastids (Plate 2, fig. 8). Between these cells there are a few young bitter-principle ducts which it is very difficult to distinguish from the parenchyma cells, owing to their close similarity in structure. They can be detected only by the absence of the chloroplastids. The starch sheath is inconspicuous. The pericycle consists of an undulated, continuous sclerenchymatous ring which is composed simply of the arcs of primary, hard bast and parenchyma cell, the latter being in the inner part (Plate 1, figs. 3 and 4). The primary vascular bundles are arranged in the form of a ring and vary in number from ten to fifteen. The wood is composed mostly of one or two spiral and annular vessels and xylem parenchyma. The pith is occupied by parenchyma cells with circular outline.

The structure of an adult stem is more characteristic and complicated. The outline of a transverse section is somewhat circular with one or two prominent projections at the side (Plate 2, fig. 6). These projections correspond to the section of the protuberances or the elevated lenticels. The bark is thick; in the region of the lenticel it is very thick. The outermost part of the cortex is limited by a thin periderm consisting of several layers of flattened cork cells and a few layers of phellogenetic cells. The periderm originates from the tangential division of the subepidermal cells; that is, at first it occurs near the region of the lenticels and then spreads peripherally (Plate 2, fig. 9). In the first division of these cells, the resulting inner daughter cells become the phellogen layer, from which

the cork cells arise. The cork cells are brownish, closely fitted, slightly suberized, and completely flattened, as indicated in Plate 2, fig. 10. When they are isolated by Schulze's maceration process, they exhibit a polygonal outline (Plate 2, fig. 11, *a* and *b*). They measure about 0.056 mm in their longest diameter, and 0.04 mm in their shortest diameter. The phelloderm is not distinct and is poorly developed in other parts of the sections.

The lenticels.—The structure of the lenticels of *Tinospora rumphii* is identical to that of the ordinary dicotyledonous plants, but they are located at the tips of the tuberclelike structures, or protuberances, found on the stems. These protuberances originate and develop from the phellogen layer. They measure about 5 mm in length (Plate 1, figs. 3 and 4, and Plate 2, fig. 6).

The cortical parenchyma.—The cortical parenchyma extends several layers of cells deep and is not limited by a distinct starch sheath. It is not uniform in thickness. In some parts it is very thick on account of the projections in which the lenticels are found. Its average thickness is about half of the diameter of the central cylinder. For convenience the cortex may be divided into, say, two regions; namely, the chlorophyllous region and the nonchlorophyllous region.

The chlorophyllous region.—The chlorophyllous region usually occupies about one-third of the cortex. It is composed of eight or more layers of parenchyma cells containing chloroplastids. These parenchyma cells have thin walls with a circular outline, and those near the phellogen are somewhat tangentially elongated. Between them there are numerous ducts, or bitter-principle sacs, which have the general appearance of ordinary parenchyma cells in cross section. They are easily distinguished from the parenchyma cells, however, because they do not contain chloroplastids, and they are usually larger and surrounded by six or eight slightly flattened parenchyma cells (Plate 2, figs. 10, 13, 14, and 15). They are very numerous in the peripheral side of the chlorophyllous region. A detailed description of their structure and development is given below.

In a cross section of a very old stem there are usually patches of stone cells in the cortex near the phellogen layer. These stone cells are sometimes found in an extended layer forming a sort of ring around the peripheral part of the cortex. They are somewhat cubical and their walls are yellowish, thick, pitted, and lignified to stony hardness. They sometimes contain large,

solitary, rhomboid or monoclinic calcium oxalate crystals, as represented in Plate 2, fig. 12.

The nonchlorophyllous region.—The nonchlorophyllous region is thicker and occupies about two-thirds of the entire cortex. It is built up entirely of thin-walled parenchyma cells without chloroplastids and between them are a few bitter-principle sacs. These parenchyma cells have very thin walls, are circular in cross section, and usually filled with abundant, small, ovoid or somewhat rounded starch grains. The cells toward the inner part, however, are sometimes radially elongated, more or less rectangular in form, and arranged in rows radiating from the crescent-shaped band of sclerenchymatous cells belonging to every vascular bundle (Plate 3, fig. 19). This arrangement of the inner parenchyma cells is especially evident in the cross section of a very old stem. Plate 3, fig. 20, is taken from a region between the cortical parenchyma and the sclerenchyma of the pericycle which shows the rectangular shape of some of the inner parenchyma cells of the nonchlorophyllous region. Adjoining the sclerenchyma band there is a layer of cells which correspond to the starch sheath, containing large, solitary, prismatic or monoclinic calcium oxalate crystals. Plate 3, fig. 21, shows a longitudinal section corresponding to fig. 20 on the same plate, cited above. It shows a row of cells, also containing calcium oxalate crystals. These rows of cells can be isolated by means of Schulze's maceration process and, when isolated, they appear as crystal fibers measuring about 0.27 mm in length (Plate 3, fig. 22).

The bitter-principle sacs.—In the cortical parenchyma of the stem, petiole, and midrib, the writer has observed some structures other than parenchyma cells which, in cross section, have the general appearance of parenchyma cells, except that they are larger; and in longitudinal section they appear as elongated vessels. These structures can be called bitter-principle sacs, owing to the fact that they possess a more or less clear or opaque mucilaginous sap containing bitter principles. According to Solereder,⁽⁹⁾ similar structures called secretory sacs were observed by Bailon in *Anamirta* and they were erroneously described by Blottiere as "Cannaux laticiferes." Solereder indicates that these secretory sacs may occur in the pith as well

as in the cortex and that they have so far been observed by him, by Blottiere, and by Volken in the following species:

<i>Anamirta cocculus</i> Wight and Arnold.	<i>Cocculus laeaba</i> de Candolle.
<i>Burasaia madagascarensis</i> de Candolle.	<i>Diploclisia macrocarpa</i> Miers.
<i>Cissampelos caapeba</i> Linnæus.	<i>Jateorrhiza palmata</i> Miers.
	<i>Limacia velutina</i> Miers.
	<i>Tinospora cordifolia</i> Miers.

The bitter-principle sacs of *Tinospora rumphii*, unlike the secretory sacs described above, occur only in the cortical region and are especially numerous in the peripheral part of the cortical parenchyma of the adult stem where the chloroplastids are abundant. They do not occur in the pith or the pith rays. A critical investigation as to their origin and development reveals that they arise and develop from the gradual and complete destruction of the cross walls of a row of parenchyma cells, as shown in Plate 2, figs. 15, 16, and 17. They possess all the characteristics of the articulated latex tubes, except that they are not greatly elongated and that they neither anastomose nor branch. They are found as independent tubes of various lengths, scattered in the cortical region of stem, petiole, and midrib. More significant evidence that they originate by the complete disappearance of the cross walls of a row of parenchyma cells is observed in the preparation made from the bark of a young and an adult stem macerated with a 2 per cent solution of potassium hydroxide. Some of the sacs are more or less isolated and their contents appear in coagulated form and are of a grayish color. Different stages of their formation are observed. A row of four or five cells may be separated and the cross walls of some of them be partially or completely dissolved as shown in Plate 2, figs. 15, 16, and 17. In the older stages of the sacs the remains of the transverse walls of the original cells cannot in most cases be traced (Plate 3, fig. 18, *a* to *c*). A microchemical test of the content of the bitter-principle sacs revealed that it has a reducing effect on Fehling's solution.

The pericycle is composed of (*a*) the sclerenchymatous crescent-shaped bands of hard bast fibers belonging to the separate vascular bundles and (*b*) parenchyma cells. These crescents of hard bast limit the outer portions of the phloëm and extend around the stem, concentric with the cambium ring (Plate 1,

figs. 3 and 4; Plate 2, figs. 6 and 8; Plate 3, figs. 19, 20, and 21). They consist of small thick-walled and lignified cells with polygonal outline in cross section and greatly elongated in longitudinal section. Their walls are slightly pitted, unbranched, and somewhat tapering at both ends (Plate 3, fig. 28). They measure about 0.02 mm in diameter and from 0.7 to 1.4 mm in length. The parenchyma cells between the crescentic bands of sclerenchymatous elements usually become sclerosed. Their walls are greatly thickened, lignified into stony hardness, and frequently with the inclusion of a large solitary monoclinic or rhomboid calcium oxalate crystal. In view of the formation of these stone cells, the crescents of sclerenchyma fibers are united and thus the pericycle appears as an undulated composite and continuous sclerenchymatous ring in structure in the old stem, which is indicated by Solereder⁽⁹⁾ as a general characteristic of menispermaceous plants.

The vascular bundles are separated from one another by broad, primary medullary rays, and they stand out distinctly even to the naked eye in a transverse section of the stem. The number of vascular bundles in an adult stem varies from 16 to 20, new bundles having been produced between the primary ones. The phloëm of the vascular bundles is a narrow zone within the pericycle. In the outer portion it is limited by large parenchyma cells with thin and delicate walls, which are usually broken or torn out in sectioning, and in the inner side it is separated from the xylem region by a cambium which consists of a layer of thin-walled, delicate, tubular cells. The phloëm is composed of sieve tubes, companion cells, and phloëm parenchyma. The phloëm cells toward the periphery are usually flattened or shriveled, forming a dark zone in the form of an arc, while those toward the cambial portion are somewhat polygonal and rectangular in outline, and frequently arranged in irregular rows.

The xylem region is composed chiefly of xylem, metaxylem, and protoxylem vessels, wood fibers, and wood parenchyma (Plate 3, figs. 19, 23, and 24). In the lateral part it is limited by a row of cells which are somewhat radially elongated, and sometimes contains some calcium oxalate crystals. The vessels are characterized by their large circular lumina, which measure from 0.15 to 0.38 mm in diameter, and are visible to the naked eye. They are usually filled with tyloses and possess thick walls with perforations. They have bordered pits, even in places

where they are found in contact with parenchyma cells. Plate 3, fig. 3, is a detailed representation of a portion of the cross section of a vascular bundle showing a large vessel filled with tyloses and surrounded by wood parenchyma. In a longitudinal section cut through the vascular bundle, these vessels appear as continuous tubes made up of rows of cells the cross walls of which have been dissolved (Plate 3, fig. 24). When macerated with nitric acid and potassium chlorate, the vessel cells exhibit a diversity of forms. They vary from a cylindrical shape, as shown in Plate 3, fig. 27, *a* and *b*, and Plate 4, fig. 30, to a barrellike or beakerlike outline with tangentially elongated pits. They measure from 0.072 to 0.26 mm in diameter and from 0.2 to 0.44 mm in length. The metaxylem and protoxylem vessels have smaller cavities and their walls possess either pitted, annular, or spiral thickening. The wood fibers or libriform fibers are thick-walled, lignified, and greatly elongated cells with simple pits. Both ends are somewhat pointed and sometimes irregularly convoluted, or wavy. They measure from 0.480 to 0.555 mm in length. The xylem parenchyma cells are short and have thin walls; they also possess simple perforations and their two ends are blunt and not tapering.

The medullary rays in cross section appear uniform in structure. They are made up of several rows of thin-walled, pitted, and radially elongated parenchyma cells. The ray cells are in most cases filled with a considerable number of starch grains. In the radial section they appear rectangular and sometimes square, with large simple pits. Plate 4, fig. 32, represents a group of ray cells isolated by Schulze's maceration process.

The central pith of the stem in cross section is somewhat circular in shape and about 3 mm in diameter. It is composed principally of thin-walled parenchyma cells with polygonal or circular outline. In a very old stem the walls of some of the parenchyma cells, however, become greatly thickened, lignified, and perforated by numerous, usually branched, pit canals of circular appearance in transverse section. These lignified cells appear in groups or patches in the pith region. Their cavities are sometimes greatly reduced when the walls become very thick and sometimes contain inclusion of large solitary rhomboid or circular appearance in transverse section. These lignified cells of a transverse section of the pith of an older stem, and fig. 26, on the same plate, represents a corresponding longitudinal section taken from the same stem. The walls of the lignified

parenchyma cells in these figures are not greatly thickened. When these cells are isolated by maceration, they exhibit a more or less rectangular shape or a beakerlike outline (Plate 4, fig. 33, *a* to *e*). Plate 4, fig. 34, is prepared from stone cells from the pith of a very old stem, isolated by maceration. Their walls are greatly thickened, striated, and with simple or branched perforations. Each of the two stone cells shown on Plate 4, fig. 35, contains a large solitary crystal in the cavity.

The starch grain.—The cells of the inner part of the cortical parenchyma, the medullary rays, and the pith are usually supplied with abundant, small, ovoid, or somewhat rounded starch grains which measure from 0.006 to 0.025 mm in diameter. These starch grains do not possess a distinct hilum and are not prominently striated.

THE LEAF

The full-grown leaves are from 8 to 16 cm long and from 10 to 14 cm wide. They are broadly ovate in outline, long petiolate, thin, glabrous, dark green and shining on the upper surface, and light green on the lower surface. The base is deeply cordate and sometimes nearly truncate. The margin is entire and the apex acuminate. At the base there are five nerves belonging to the first order (Plate 1, fig. 1). The petioles are from 5.5 to 10.5 cm long, and about 2 mm in diameter, nearly cylindric or somewhat angular, with a narrow and slightly elevated ridge in the upper part. When the fresh leaves are crushed between the fingers, the odor is not characteristic, but the taste is very bitter.

The structure of the leaf.—The leaf structure of *Tinospora rumphii* Boerlage in transverse section is bifacial. The mesophyll is rather uniform in thickness and measures about 0.165 mm. The upper epidermis is composed of a single layer of tangentially elongated, rectangular, and sometimes nearly square cells with thick and cutinized outer cell walls. These cells in most cases contain monoclinic or prismatic calcium oxalate crystals (Plate 4, fig. 36). The lower epidermis also consists of a layer of cells, of the same shape and with some calcium oxalate crystal inclusion, but with very much thinner and less-cutinized outer cell walls. The palisade chlorenchyma occupies about one-fourth of the section, and consists of a single row of perpendicularly elongated or tubular cells, about 0.05 mm in length and 0.01 mm in diameter, and formed just below the upper epidermis. The spongy chlorenchyma is made up of irregularly

shaped parenchyma cells of various sizes and with few chloroplastids. It is about twice as thick as the palisade region and measures about 0.108 mm thick. Along this part of the mesophyll, there are at regular intervals remarkably large intercellular spaces of a circular or somewhat horizontally elongated outline in cross section (Plate 4, fig. 36). These air spaces measure from 0.120 to 0.150 mm in diameter and communicate with the smaller intercellular spaces between the spongy parenchyma cells. The epidermal outgrowths consist chiefly of multicellular, uniseriate glandular hairs of from two to three cells and are observed only in the lower epidermis. The capitate part of these hairs is nearly rounded in shape (Plate 4, fig. 38).

In the surface preparations, the epidermal cells appear polygonal in outline with from five to seven straight, thick walls. They are 0.025 to 0.043 mm in their longest diameter and from 0.018 to 0.032 mm in their shortest diameter. The calcium oxalate crystals observed in the cross section are more evident and better displayed in this preparation, as indicated in Plate 4, fig. 37. The lower epidermal cells are also polygonal in outline and are richly supplied with calcium oxalate crystals, but they are smaller and their walls are thinner and more or less wavy (Plate 4, fig. 38). They measure from 0.036 to 0.101 mm in their longest diameter and from 0.018 to 0.036 mm in their shortest diameter. The stomata are confined in the lower surface of the leaf. They occur in patches in the area between the veinules. Their sizes are not uniform and they vary from 0.025 to 0.032 mm in length and from 0.021 to 0.027 mm in width. They are surrounded by from three to six neighboring cells. One of the neighboring cells is invariably smaller than the others, and this smallest neighboring cell is usually applied vertically to the length of the guard cells. The glandular hairs are better observed in this surface preparation than in the cross section.

The midrib is slightly convex above and strongly convex below. The outline in the lower part is irregularly wavy (Plate 4, fig. 36). The ventral epidermis as well as the dorsal consists of a single layer of cells, rectangular or nearly square in outline. The outer cell walls of the upper epidermis are comparatively thicker and more cutinized than are those of the lower epidermis. Some of those of the lower epidermis are papillose in nature; that is, they exhibit slight outgrowths or projections. The collenchyma cells are present in two distinct regions, above and below the midrib, just inside the epidermis. In the inner

part of these cells toward the stele is a region of cortical parenchyma consisting of thin-walled cells. Here and there, in this parenchyma region, there are some bitter-principle sacs. The meristele is somewhat fan-shaped or nearly circular. The upper part is bounded by a group of small, thin-walled parenchyma cells, which are polygonal in outline. The xylem is composed of large vessels, from 0.025 to 0.043 mm in diameter, and xylem parenchyma. Below the xylem is the phloëm region, which is made up of the same type of cells as is the phloëm of the stem. The phloëm is usually traversed by a row of parenchyma cells or pith-ray cells. The outer part of the phloëm consists of a few layers of parenchyma cells which are limited by two or three layers of colorless, slightly lignified sclerenchyma fibers, forming a sort of arc in the lower part of the vascular bundle.

The petiole.—The structure of the petiole is very similar to that of the stem. In cross section it appears as a somewhat circular and wavy outline, and contains a circular system of isolated vascular bundles, which vary from six to eight in number. The epidermal cells are more or less isodiametric in nature and some contain calcium oxalate crystals. The cortex is thick, consisting of two or three layers of collenchyma cells, and a few layers of chlorenchyma. Between these cells are also some bitter-principle ducts. The starch sheath is not distinct. The pericycle, like that of the stem, consists of a continuous, undulate sclerenchyma band. Plate 4, fig. 39, is a diagrammatic representation of a cross section of a petiole traced under a 48-millimeter objective with the aid of a camera lucida. The vascular bundles are separated by the medullary rays and the pith, which is nearly circular in outline, is large.

TINOSPORA RETICULATA MIERS

THE STEM

The young, fresh stems of *Tinospora reticulata* Miers have almost the same general appearance as have those of *Tinospora rumphii* Boerlage. The former differ, however, from the latter in that the leaves have a truncate or sometimes slightly cordate base (Plate 5, fig. 40, *a* and *b*). Moreover, when these young stems are cut, they exude a clear, mucilaginous, and tasteless or very slightly sweetish juice.

The adult stems of *Tinospora reticulata*, on the other hand, are rather different from the stems of *Tinospora rumphii* in various features. In the first place, the stems of the former

have fewer and less-prominent protuberances than are observed in the latter. In the second place, the stems of *Tinospora reticulata* vary from straw or brownish yellow to greenish sepia color, with whitish or grayish lichen patches in some places, while those of *T. rumphii* are usually dark green or brownish green. Both types of stems, however, are invested with very thin cork which peels off in flakes, and they are leafless. When bent they are somewhat flexible. Perhaps the most significant difference between the two species lies in the relative amount and taste of their sap. When the stems of *T. reticulata* are cut, they exude a scanty, clear, and very slightly bitter, mucilaginous sap, while those of *T. rumphii*, when cut, as indicated above, exude abundant mucilaginous sap, of a somewhat milky or turbid appearance and with a very bitter taste. When dry the stems of *T. reticulata* shrink but slightly and the bark is more or less separated from the wood. Their color remains almost the same, while the odor is also not at all characteristic.

Structure of the stem.—The structure of a transverse section of a young stem of *Tinospora reticulata* is practically identical with that of the young stem of *T. rumphii*. The only difference is that in *T. reticulata* the cortical parenchyma is relatively thinner and does not contain so many bitter-principle sacs. The glandular hairs are apparently less numerous and sometimes are not observed in the cross sections.

The structure of the adult stem is just as complicated and interesting as is that of the species *T. rumphii* (Plate 5, fig. 41). The outline of a transverse section is also circular with one or two slight projections due to the elevated lenticels. The bark, however, is very much thinner than that of *T. rumphii* and is about one-fifth of the diameter of the central cylinder. Plate 6, fig. 43, is a portion of the cortical parenchyma showing (1) the periderm, consisting of slightly suberized epidermal and subepidermal cells, several layers of flattened cork cells (see also Plate 6, fig. 44, *a* and *b*), a few layers of phellogenetic cells, and phellogen layer; (2) the calcium oxalate crystal ring which is made up of a layer of cells interior to the phellogen region containing large, solitary or small-clustered monoclinic, prismatic or rhomboid calcium oxalate crystals (see also Plate 6, fig. 45); (3) the patches of stone cells found scattered in the peripheral part of the cortical outside of the chlorophyllous region, which are also observed in the case of *T. rumphii*; (4) the chlorophyllous region which has an almost uniform structure consisting simply of small thin-walled, isodiametric

parenchyma cells containing chloroplastids and one inconspicuous bitter-principle sac; and (5) a portion of the nonchlorophyllous region made up of large parenchyma cells containing some small ovoid or oblong ovoid starch grains. The inner layers of cells of this region, like those of the corresponding region in *T. rumphii*, are usually arranged in rows and radiating from the sclerenchyma bands; the only difference is that the parenchyma between these sclerenchyma bands becomes sclerosed earlier than does that of *T. rumphii*. Plate 6, fig. 52, represents a portion of the parenchyma cells between the sclerenchyma bands corresponding to two vascular bundles, showing a group of cells becoming lignified with some large calcium oxalate inclusions.

The lenticels.—The structure of the lenticels of the stem of *T. reticulata* is almost identical to that of *T. rumphii*, but the lenticels of the former are not greatly elevated, as are those of the latter (Plate 5, figs. 40e and 41).

The bitter-principle sacs observed in the stems of *T. rumphii* are also found in a very old stem of *T. reticulata*, but they are comparatively fewer in number and are not usually conspicuous in cross section or in the longitudinal section of the stem (Plate 6, figs. 43 and 47). This finding is corroborated when the sap of the old stem is tasted, which is slightly bitter. These bitter-principle sacs found in *Tinospora reticulata* seem to develop only in the older stems and are not found in the leaves and the young stems. They originate and develop in the same way as do those of *T. rumphii*. In the preparations macerated with potassium hydroxide they appear as greatly elongated tubes containing a greenish, somewhat homogenous content, with large globules, oily in appearance. They simulate the ordinary unbranched laticiferous vessels (Plate 6, figs. 46 and 48). Microchemical test proves that the content of these sacs has only a very slight reducing effect on Fehling's solution.

The structure of the pericycle of *T. reticulata* is practically the same as that of *T. rumphii*. In Plate 6, fig. 49, is seen a portion of the transverse section of the pericycle showing the characteristic layer of cells containing solitary, large calcium oxalate crystals which are found limiting the outer part of the lignified, thick-walled sclerenchyma band. Plate 6, fig. 46, shows a portion of a longitudinal section corresponding to the region shown in fig. 49, and fig. 51 shows a crystal fiber isolated

by Schulze's maceration process from the outer part of a sclerenchyma band.

The vascular bundles of *T. reticulata* are about fourteen in number and they are characterized and distributed in the same way as are those of *T. rumphii*. The only, slight difference observed is that the lateral parts are limited by a row of cells usually containing prismatic or monoclinic prismatic crystals of calcium oxalate, as indicated in Plate 6, fig. 53. The vessels, the phloëm cells, wood fibers, and wood parenchyma have practically the same characteristics as have those of *T. rumphii* (Plate 6, figs. 53 and 54, *b* to *d*; and Plate 7, figs. 56, *a* to *c*, and 57).

The pith rays and the pith of *T. reticulata* are characterized by and composed of the same type of cells as are the pith rays and pith of the species *T. rumphii*. The lignification of some of the pith cells in the stems of *T. reticulata*, however, usually takes place earlier than in the stems of *T. rumphii*. Plate 7, figs. 60 and 61, shows cross section and longitudinal sections cut through the pith of an adult stem showing the characteristics of the lignified cell. When these pith stone cells are isolated by maceration they appear as shown in Plate 7, fig. 59, *a* to *b*. In Plate 7, fig. 58, *a* to *d*, are shown four isolated lignified cells from the pith of a younger stem showing the same characteristics as those observed in *T. rumphii* during the early stage of the lignification.

THE LEAF

The full-grown leaves of *T. reticulata* Miers measure from 10 to 13.5 cm long and from 8.5 to 10.5 cm wide. They are ovate in outline, long petiolate, thick, glabrous, somewhat coriaceous, light green and shining on the upper surface, and lighter green on the lower surface. The base is truncate and sometimes slightly cordate (Plate 5, fig. 40, *a* and *b*). The margin is entire and somewhat deflexed, and the apex is acuminate. At the base, as in *T. rumphii*, there are five nerves of the first order. The petioles are from 3.5 to 6.5 cm long, and about 1.8 mm in diameter, nearly cylindric or slightly angular. When the fresh leaves are crushed between the fingers, the odor is not characteristic and the taste is slightly sweetish.

Structure of the leaf.—The leaf structure of *Tinospora reticulata* is very similar to that of *Tinospora rumphii*. The only difference is that the mesophyll of the former is thicker and the

air spaces, which are more or less arranged at regular intervals along the spongy region, are smaller than in the latter (Plate 7, fig. 62). The mesophyll of *T. reticulata* is about 0.18 mm thick and the palisade chlorenchyma 0.05 mm long and 0.01 mm in diameter. The upper and lower epidermis do not contain monoclinic or prismatic calcium oxalate crystals.

In the surface preparation, the upper epidermal cells of *T. reticulata* appear almost like the upper epidermal cells of *T. rumphii*, except that those of the former are larger and usually contain a few calcium oxalate crystals in a more or less raphide form. They measure from 0.054 to 0.072 mm in their longest diameter and from 0.029 to 0.054 mm in their shortest diameter (Plate 7, fig. 63). In the lower epidermis the cells of the former are smaller than are those of the latter and they frequently contain calcium oxalate crystals in the form of raphides (Plate 7, fig. 64). The stomata are almost the same in number, but those of *T. reticulata* are larger. They measure from 0.029 to 0.036 mm in length and from 0.021 to 0.03 mm in diameter. The glandular hairs in *T. reticulata* are usually composed of three cells and are more numerous than in *T. rumphii*.

In *T. rumphii* it is rather difficult to separate the upper epidermis from the mesophyll while the lower epidermis is easily removed. In *T. reticulata*, however, it is just the reverse; the upper epidermis is easily separated from the mesophyll while it is rather difficult to remove the lower epidermis.

The structure of the midrib is very similar to that of *T. rumphii*. The only differences are the presence of some sclerenchymatous cells in the upper and lower parts of the conducting tissue and the absence of the elongated bitter-principle sacs. Moreover, the outline of the lower part of the midrib is more or less uniform in *T. reticulata*.

The petiole.—There are no significant differences between the two plants except that in the cortical region of *T. rumphii* there are some elongated bitter-principle sacs and the number of the vascular bundles in *T. reticulata* varies from 8 to 11. In the arrangement and distribution of the vascular bundles and in the presence of the undulate sclerenchymatous ring of the pericycle, the plants are very similar.

SUMMARY AND CONCLUSIONS

1. Grown under the same conditions, the adult stems of *Tinospora rumphii* Boerlage are distinguished from the stems of

Tinospora reticulata Miers by the facts that those of the former have usually a dark green color, and are succulent and covered with numerous, prominent protuberances at the tip of which the lenticels are found, while the stems of the latter are straw or sepia green in color with fewer protuberances.

2. The stems of the two plants are invested with a very thin cork which peels off in flakes, and both are leafless.

3. The stems of *Tinospora rumphii* possess abundant, somewhat milky or turbid mucilaginous juice with a very bitter taste, while those of *Tinospora reticulata* contain only scanty, clear, and somewhat sweetish or bitterish mucilaginous sap.

4. The periderm in the two plants is very similar. In both it originates and develops from the subepidermis and is made up of several layers of completely flattened, slightly suberized cork cells and phellogenetic cells.

5. The cortical parenchyma of *Tinospora rumphii* is fairly thick and contains abundant bitter-principle sacs, while that of *Tinospora reticulata* is thinner and possesses much fewer bitter-principle sacs. Besides, the outer part of the cortex of the latter contains a layer of cells in the periphery with calcium oxalate inclusions.

6. The bitter-principle sacs originate from the disappearance of the cross walls of a row of cortical parenchyma cells.

7. The pericycle in the two plants is almost identical; in both it shows an undulated composite and usually continuous sclerenchymatous ring.

8. The vascular bundles in both species are separated from one another by broad primary medullary rays and stand out distinctly in transverse section. The xylem vessels are usually filled with tyloses, while the pith rays are filled with starch grains.

9. Some of the cells in the pith of the two stems are observed to become lignified. Those of *Tinospora reticulata*, however, become lignified earlier than do those of *Tinospora rumphii*.

10. The leaves of *Tinospora rumphii* are deeply cordate, while those of *Tinospora reticulata* have a truncate or sometimes slightly cordate base.

11. The leaf structure of *Tinospora rumphii* is somewhat similar to that of *Tinospora reticulata*, but the former has a thinner mesophyll and large rounded air spaces at regular intervals along the spongy region, while the latter has a thicker mesophyll which has smaller air spaces.

12. The upper epidermis and the lower epidermis of *Tinospora rumphii* are very similar to those of *Tinospora reticulata*, but those of the former are richly supplied with monoclinic or prismatic calcium oxalate crystals, while those of the latter contain only a few calcium oxalate crystals in raphides.

13. There are some bitter-principle sacs in the cortical region of the midrib of *Tinospora rumphii* and the sclerenchymatous cells are found only in the lower part of the conducting tissue, while that of *Tinospora reticulata* does not possess bitter-principle sacs at all in the cortical parenchyma, but the sclerenchymatous cells are found in two regions in the upper and lower parts of the conducting tissue.

14. The structure of the petiole in *Tinospora rumphii* is very similar to that in *Tinospora reticulata*, except that the former has some bitter-principle sacs in its cortical parenchyma.

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ILLUSTRATIONS

[All microscopic drawings by the author. The macroscopic drawings for Plates 1 and 5 were made by Macario Ligaya, of the Bureau of Science. The photograph for Plate 1 was made by Jesus Redondo, of the Department of Botany, University of the Philippines.]

PLATE 1. TINOSPORA RUMPHII BOERLAGE

- FIG. 1. A habit sketch of a portion of the plant. $\times \frac{1}{2}$.
2. A photograph of a portion of an adult stem as sold in the market.
3. A diagrammatic sketch of a transverse section of a young stem; *l*, young lenticel; *scl*, sclerenchyma ring of the pericycle; *vb*, vascular bundles. $\times 15$.
4. A diagrammatic sketch of a transverse section of an older stem showing an elevated lenticel. $\times 15$.
5. A very small portion of the cortex of a young stem with *co*, calcium oxalate crystal deposits, in the epidermal cells. $\times 105$.

PLATE 2. TINOSPORA RUMPHII BOERLAGE

- FIG. 6. A diagrammatic drawing of a transverse section of an adult stem; *l*, lenticel; *bs*, bitter-principle sacs; *scl*, sclerenchyma band. $\times 3$.
7. A small portion of the surface view of the epidermal cells of a young stem; *co*, calcium oxalate crystals. $\times 70$.
8. A portion of the cortical parenchyma of a young stem; *g*, glandular hair; *co*, calcium oxalate crystals; *bs*, bitter-principle sac; *scl*, sclerenchyma cells.
9. A very small portion of a transverse section cut through a young stem showing the formation of periderm; *p*, phellogen. $\times 300$.
10. A portion of a transverse section of the cortical parenchyma; *k*, flattened cork cells; *p*, phellogen; *bs*, bitter-principle sacs; *sg*, starch grains. $\times 158$.
11. *a* and *b*, a group of cork cells isolated by maceration. $\times 200$.
12. A portion of the cortical parenchyma near the phellogen region showing *sc*, group of stone cells, and *co*, calcium oxalate crystals. $\times 158$.
13. A transverse section of a bitter-principle sac. $\times 300$.
14. A longitudinal section of a bitter-principle sac. $\times 200$.
15. A longitudinal section of a young bitter-principle sac, showing method of formation. $\times 353$.
16. An isolated young bitter-principle sac, showing the gradual disappearance of cross walls. $\times 300$.
17. Another isolated young bitter-principle sac, showing the disappearance of cross walls. $\times 300$.

PLATE 3. TINOSPORA RUMPHII BOERLAGE

- FIG. 18. *a* to *c*, three mature bitter-principle sacs from the cortex of an adult stem. $\times 300$.
19. A transverse section of a vascular bundle; *scl*, sclerenchyma band; *ph*, phloem; *mv*, metaxylem vessel with tyloses; *wf*, wood fibers; *px*, protoxylem; *pr*, pith ray cells. $\times 34$.
20. A portion of a transverse section of the pericycle and cortex; *sg*, starch grain; *co*, calcium oxalate crystals; *scl*, sclerenchyma cells. $\times 300$.
21. A portion of the longitudinal section cut through the same region as shown in fig. 20; *co*, calcium oxalate crystals; *scl*, sclerenchyma fibers; *sg*, starch grains. $\times 200$.
22. A crystal fiber isolated by maceration from the outer part of the sclerenchyma band. $\times 200$.
23. A portion of the transverse section of a vascular bundle; *co*, calcium oxalate crystal; *mv*, metaxylem vessel; *pr*, pith ray cells. $\times 158$.
24. A longitudinal section through the metaxylem region. $\times 200$.
25. A portion of the transverse section of the pith showing *sc*, some cells becoming lignified. $\times 94$.
26. A longitudinal section corresponding to fig. 25. $\times 94$.
27. *a* and *b*, isolated vessel cells. $\times 94$.
28. A group of sclerenchyma fibers isolated by maceration. $\times 94$.

PLATE 4. TINOSPORA RUMPHII BOERLAGE

- FIG. 29. A group of cells isolated by maceration; *a* to *c*, wood fibers; *d* and *f*, xylem parenchyma; *e*, a tracheid with spiral thickening. $\times 120$.
30. An isolated vessel cell. $\times 120$.
31. A group of parenchyma cells from the lateral part of a vascular bundle containing calcium oxalate crystals. $\times 387$.
32. A group of medullary ray cells with simple pits. $\times 387$.
33. *a* to *e*, a group of isolated lignified parenchyma cells from the pith of a young stem. $\times 120$.
34. A group of stone cells from the pith of an adult stem. $\times 120$.
35. A group of stone cells from the pith of an adult stem containing calcium oxalate crystals. $\times 456$.
36. A transverse section cut through the midrib; *col*, collenchyma cells; *scl*, sclerenchyma band; *bs*, bitter-principle sacs; *as*, air spaces. $\times 90$.
37. A surface section of the upper epidermis; *co*, calcium oxalate crystals. $\times 236$.
38. A surface section of the lower epidermis; *g*, glandular hair. $\times 236$.
39. A transverse section of a petiole; *bs*, bitter-principle sacs; *vb*, vascular bundle. $\times 11.6$.

PLATE 5. *TINOSPORA RETICULATA* MIERS

- FIG. 40. *a*, a habit sketch of a portion of the plant showing male inflorescence, $\times \frac{1}{2}$; *b*, a detached mature leaf with slightly cordate base, $\times \frac{1}{2}$; *c*, a single male flower, $\times 4\frac{1}{2}$; *d*, a single wide open male flower, $\times 4\frac{1}{2}$; *e*, a portion of an adult female stem bearing a cluster of fruits, $\times \frac{1}{2}$.
41. A diagrammatic drawing of a transverse section of an adult stem; *l*, lenticel; *scl*, sclerenchyma band. $\times 4\frac{1}{2}$.
42. A group of cells taken from near the phellogen region and just outside of the cortical parenchyma; *co*, calcium oxalate crystals. $\times 450$.

PLATE 6. *TINOSPORA RETICULATA* MIERS

- FIG. 43. A portion of a transverse section of the cortical parenchyma; *e*, epidermis; *k*, flattened cork cells; *co*, calcium oxalate crystals; *sc*, stone cells; *g*, starch grain. $\times 156$.
44. *a* and *b*, a group of cork cells isolated by maceration. $\times 224$.
45. A group of stone cells isolated from the cortical parenchyma; *co*, calcium oxalate crystal. $\times 416$.
46. A longitudinal section of a young bitter-principle sac, showing method of formation. $\times 416$.
47. A transverse section of a bitter-principle sac. $\times 416$.
48. A portion of an isolated bitter-principle sac. $\times 416$.
49. A portion of a transverse section of the pericycle and cortex; *co*, calcium oxalate crystal; *scl*, sclerenchyma cells. $\times 336$.
50. A portion of the longitudinal section cut through the same region as shown in fig. 49; *co*, calcium oxalate crystal; *scl*, sclerenchyma fibers. $\times 224$.
51. A crystal fiber isolated by maceration from the outer part of the sclerenchyma band. $\times 224$.
52. A group of parenchyma cells which became lignified, found between two sclerenchyma bands in a transverse section; *co*, calcium oxalate crystals; *sc*, stone cells. $\times 224$.
53. A portion of a transverse section of a vascular bundle; *co*, calcium oxalate crystals; *mv*, metaxylem vessel with tyloses; *pr*, pith ray cells. $\times 156$.
54. A group of cells isolated by maceration; *a*, sclerenchyma fibers; *b*, xylem parenchyma; *c*, a tracheid with spiral thickening; *d*, a vessel cell. $\times 104$.

PLATE 7. *TINOSPORA RETICULATA* MIERS

- FIG. 55. A portion of a transverse section of the pith; *sc*, parenchyma cells becoming lignified. $\times 112$.
56. *a* to *c*, a group of isolated wood fibers. $\times 112$.
57. An isolated vessel cell. $\times 112$.
58. *a* to *d*, a group of isolated lignified parenchyma cells from the pith of a young stem. $\times 112$.

- FIG. 59. *a* to *c*, a group of stone cells from the pith of an adult stem. $\times 112$.
60. A transverse section cut through the pith of an adult stem; *sc*, stone cell. $\times 112$.
61. A longitudinal section corresponding to fig. 56; *co*, calcium oxalate crystal; *sc*, stone cell. $\times 112$.
62. A transverse section cut through the midrib; *col*, collenchyma; *scl*, sclerenchyma band; *as*, air space. $\times 362$.
63. A surface section of the upper epidermis. $\times 221$.
64. A surface section of the lower epidermis; *g*, glandular hair; *co*, calcium oxalate crystals in raphides. $\times 221$.

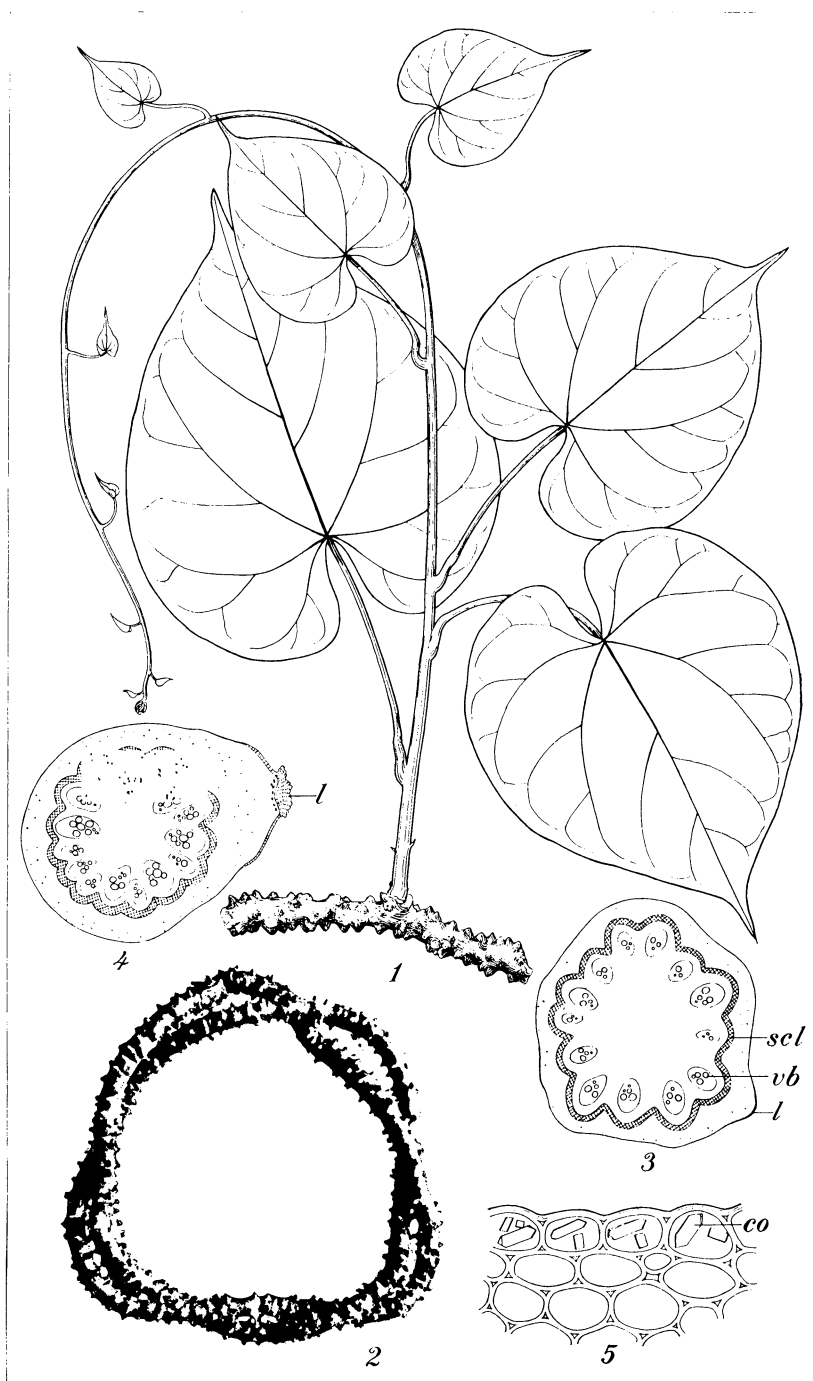


PLATE 1.

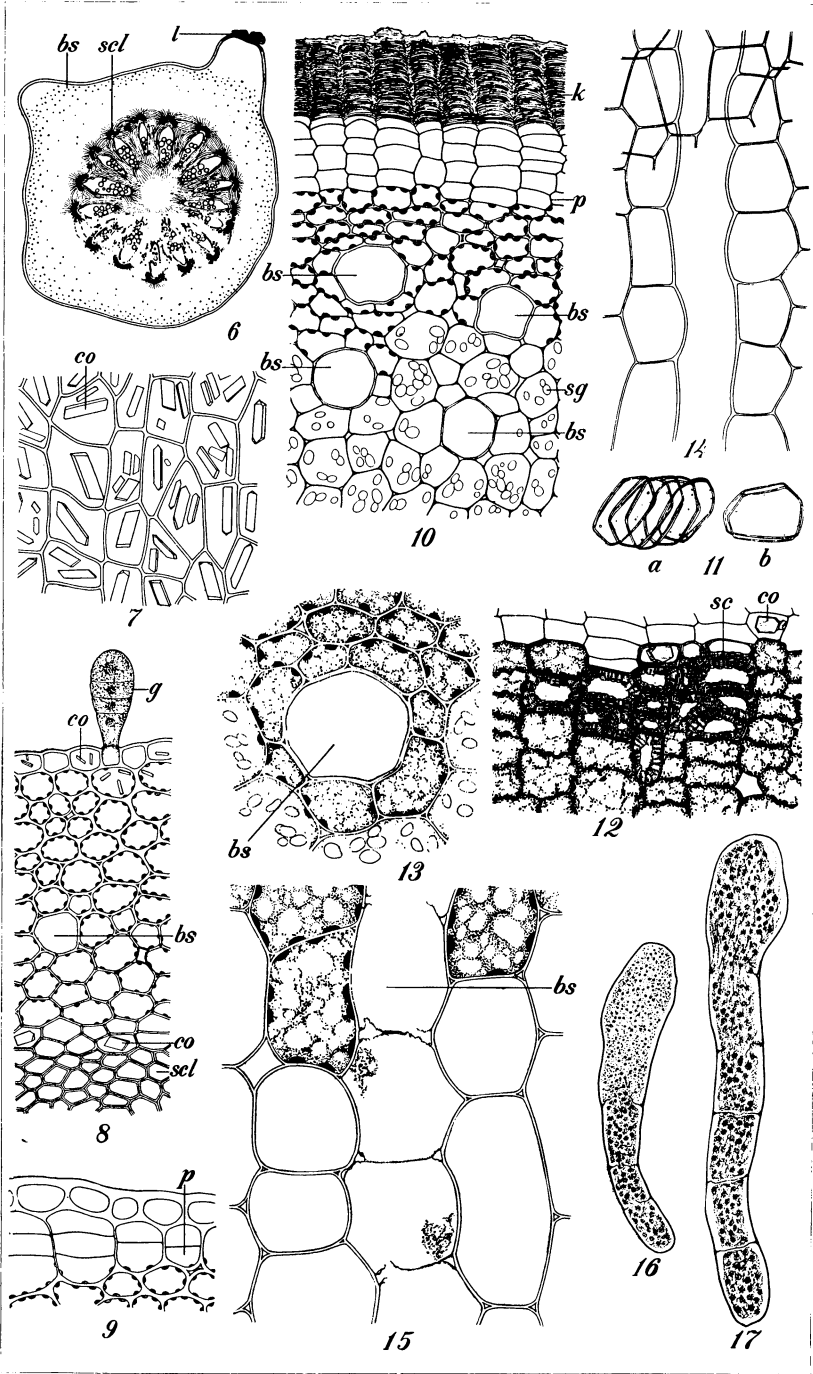


PLATE 2.

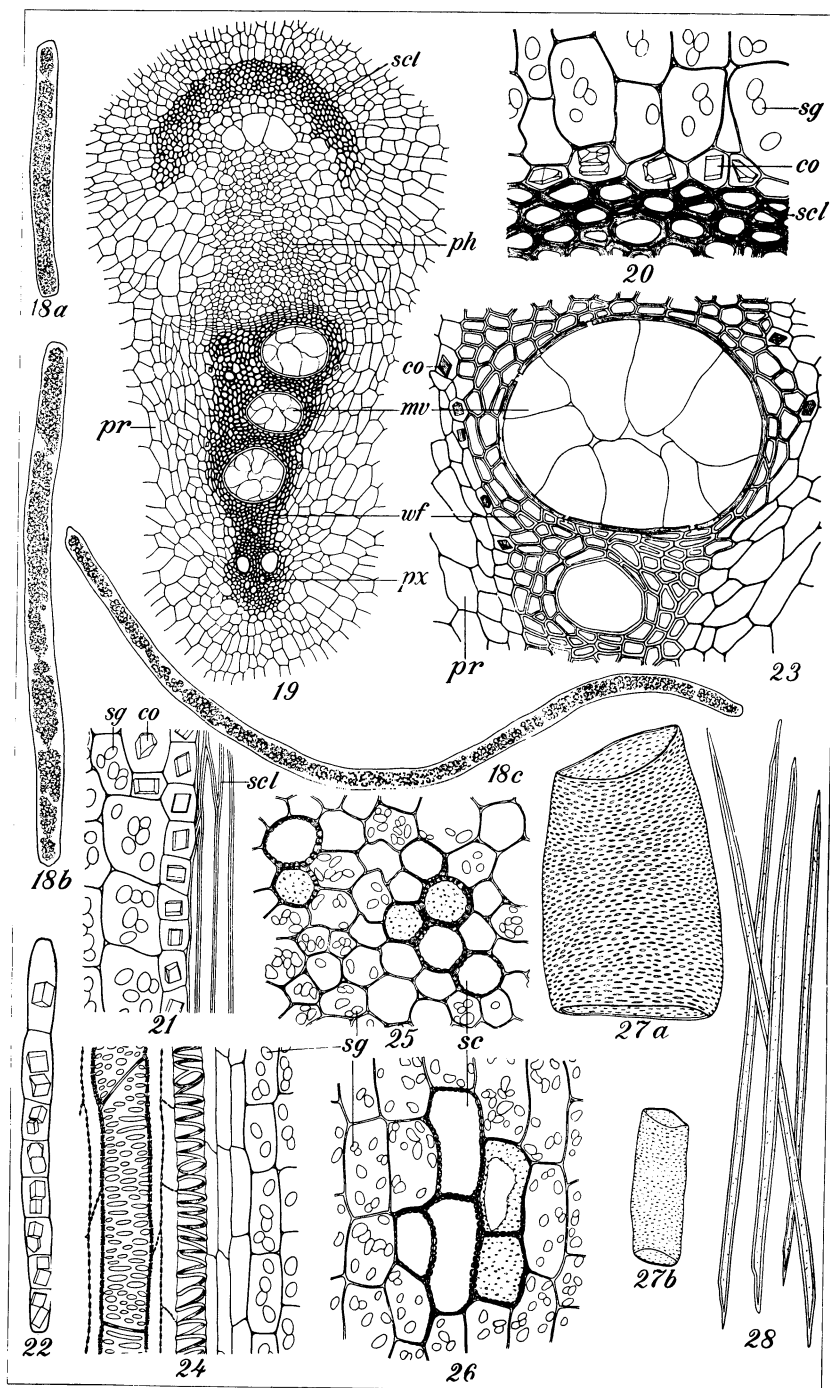


PLATE 3.

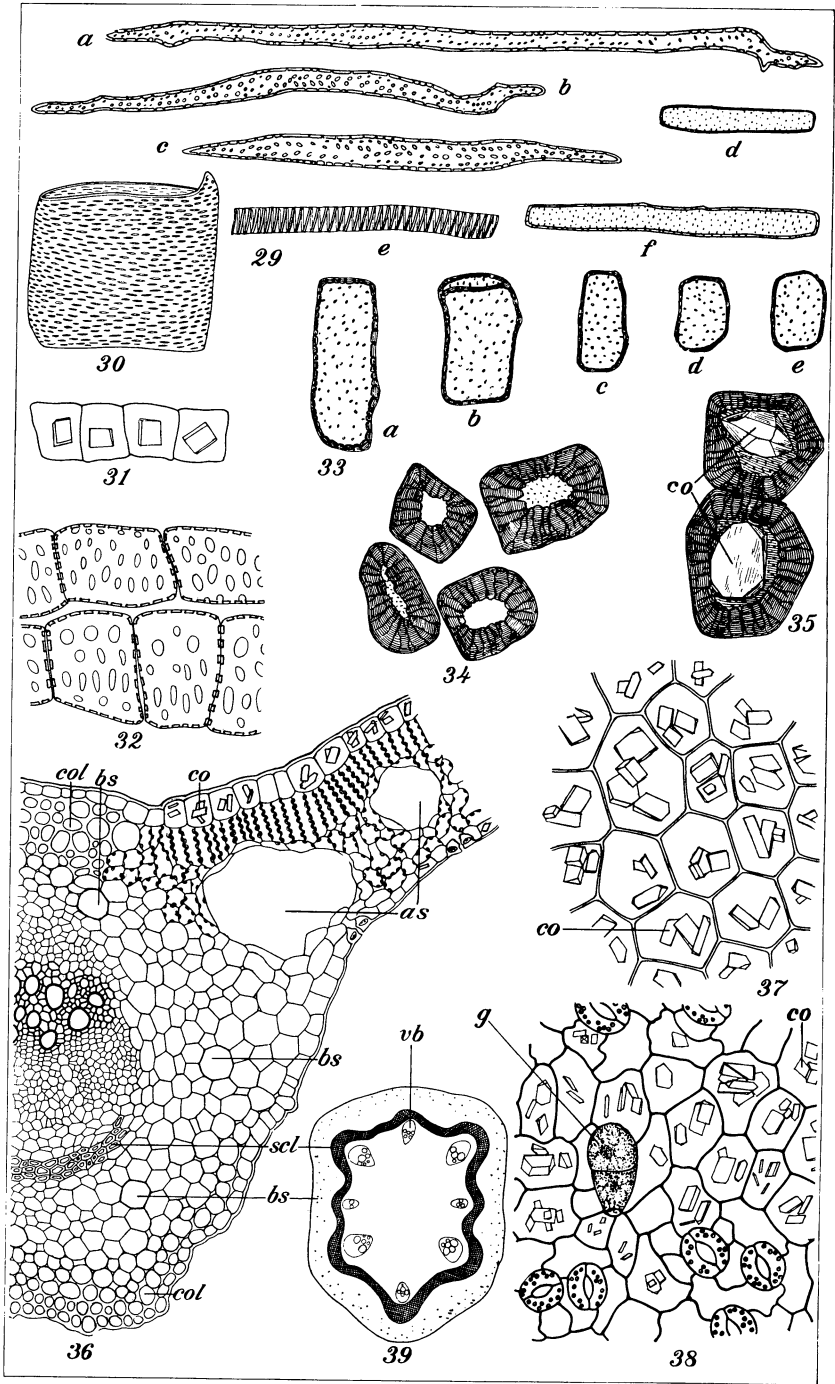


PLATE 4.

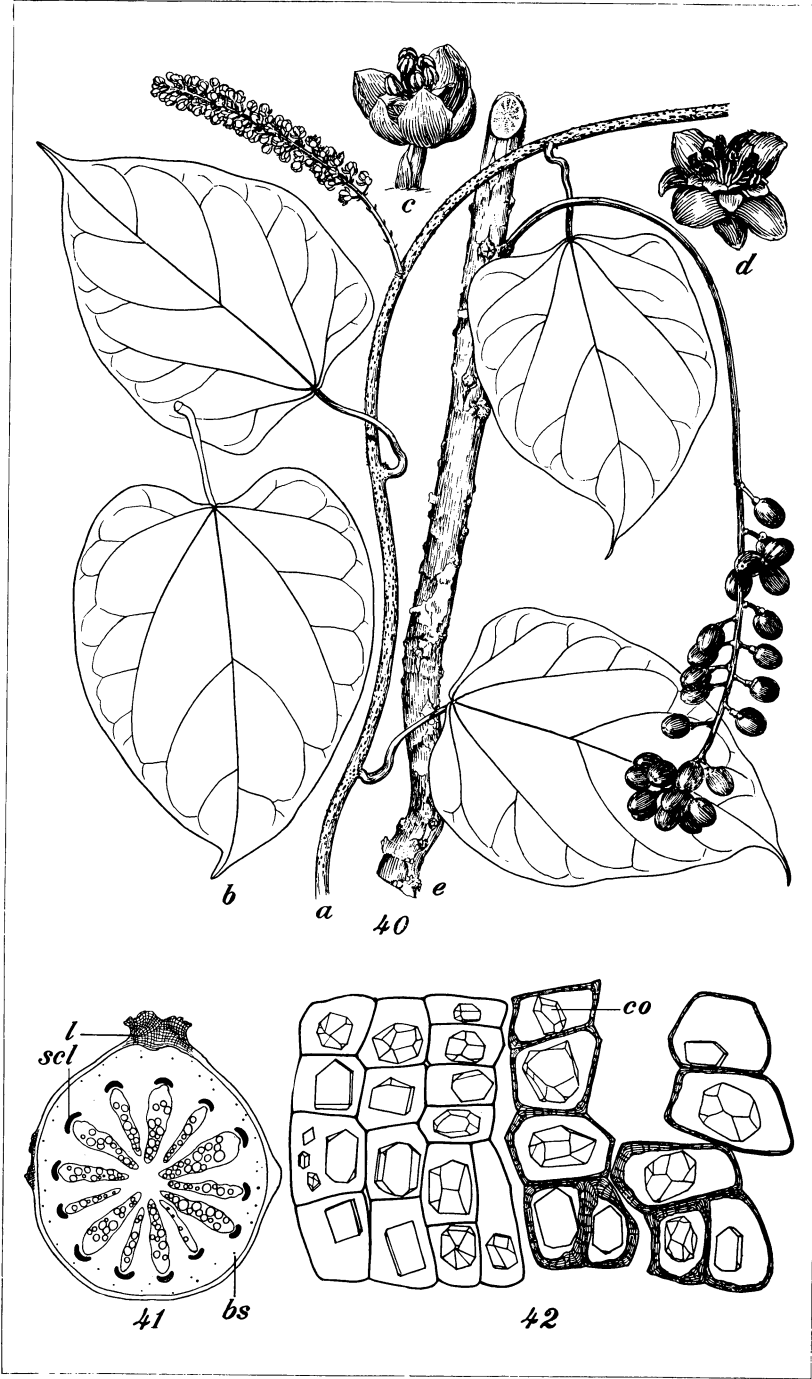


PLATE 5.

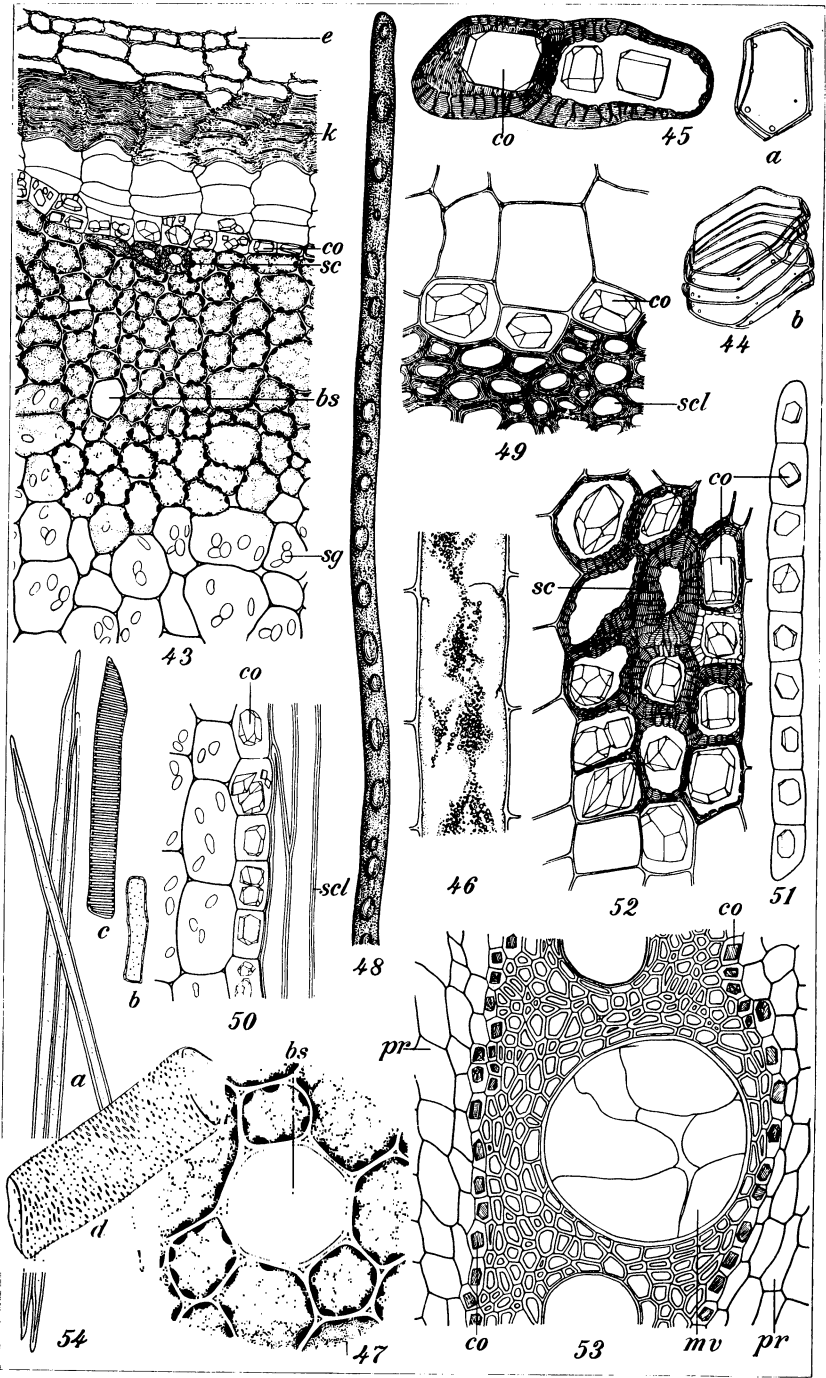


PLATE 6.

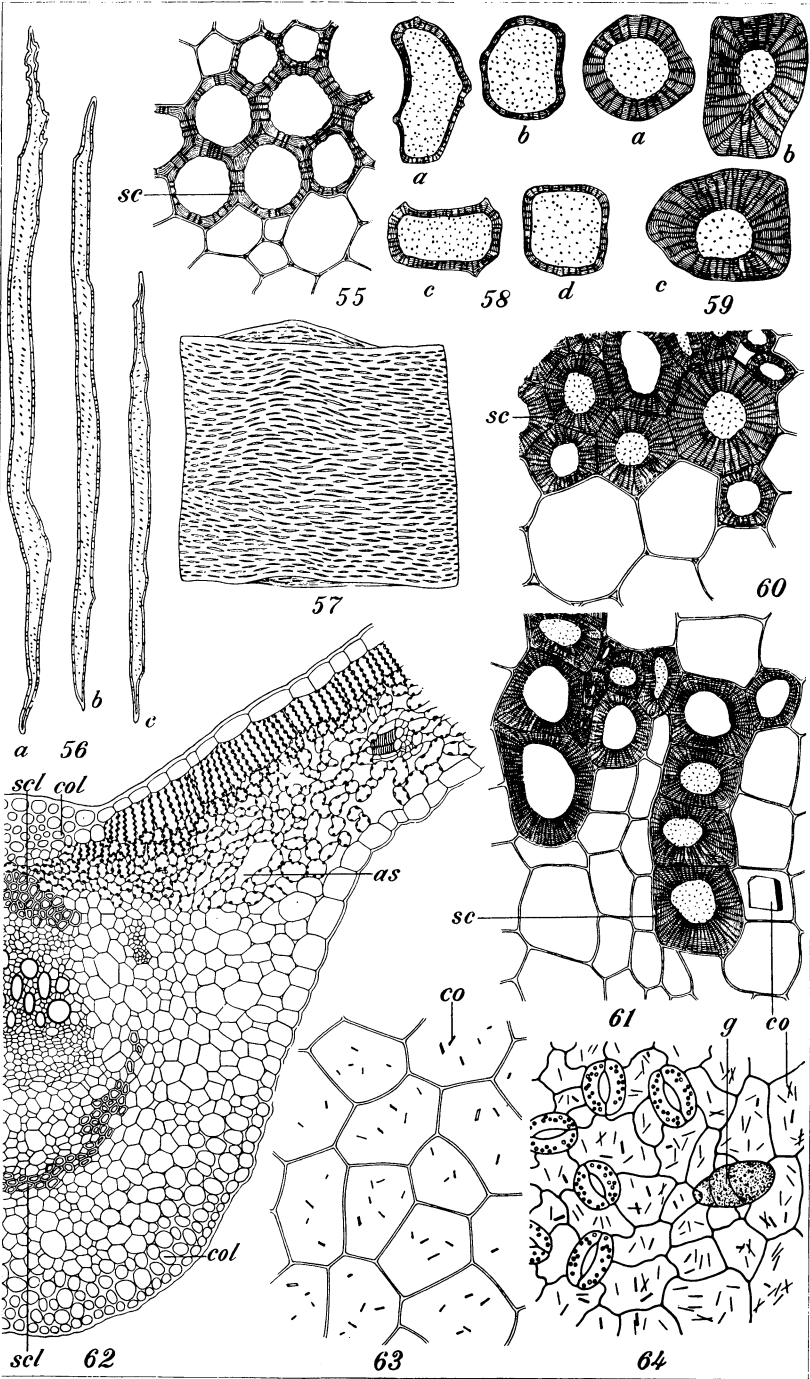


PLATE 7.

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EXPERIMENTAL YAWS IN PHILIPPINE MONKEYS AND A CRITICAL CONSIDERATION OF OUR KNOWLEDGE CONCERNING FRAMBÆSIA TROPICA IN THE LIGHT OF RECENT EXPERIMENTAL EVIDENCE

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THIRTY PLATES AND ONE TEXT FIGURE

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INTRODUCTION

The disease known as frambœsia tropica, or yaws, presents no practical problem to the practitioner. The etiology of the disease has been established and it is one of the easiest, if not the easiest, of the systemic diseases of man to cure. Therefore, it would at first sight seem superfluous to conduct experiments in quest of further knowledge of a disease the basic facts concerning which appear to be so well established. However, as will be seen, there are several points of importance as well as of interest that require elucidation. The literature on experimental yaws is very limited in comparison with that concerning experimental syphilis. We may safely state that, in this and many other tropical countries, there are far more people affected by yaws than by syphilis. Castellani⁽³⁾ said in 1906 that "numerous experiments are necessary;" Ashburn and Craig⁽¹⁾ remarked in 1907, "The literature relating to the production of frambœsia in monkeys * * * is very limited;" and Sellards and Goodpasture⁽²⁹⁾ in 1923 complain that "the experimental data are extremely meager" and "the evidence of tertiary manifestations rests chiefly upon clinical grounds and not upon any exact demonstration in the laboratory."

From the epidemiologic viewpoint the mode of transmission of the disease among humans is not very clear. The question of immunity is unsettled. Moreover, the question of the relation of yaws to syphilis still awaits an answer.

DISCUSSION OF THE PROBLEM

The problem as it presents itself for experimental study on animals is best made evident by a critical analysis of the experiments already performed by various authors who, in particular, have inquired into the problems of cross immunity and the question of the identity of frambœsia and syphilis. Shortly after the discovery by Castellani of the cause of yaws, several groups of investigators undertook the experimental study of the disease. Inspection of the available literature makes it apparent that the outstanding workers in this field are considered to be Neisser et al.,⁽²⁰⁾ in Java; Castellani,⁽⁵⁾ in Ceylon; Levaditi et al.,⁽¹³⁾ in France; and Ashburn and Craig,⁽¹⁾ in the Philippines. These investigations, as already stated, were begun shortly after the discovery by Castellani of *Treponema pertenue*; that is, in 1906 and 1907. Notwithstanding the lapse of two decades, this work still is being quoted in textbooks and other

publications as though the problem of immunity and, consequently, the question of the nonidentity of yaws and syphilis had been settled beyond peradventure at that early period. It soon becomes evident to anyone who undertakes a critical analysis of these early experiments that these several groups of students arrived at conclusions that may be mildly characterized as contradictory. That is, in some instances their findings are in agreement and in others they are in disagreement with experimental observations made on yaws as the disease occurs in man. The results of experimentation with yaws on the human subject are no less confusing; nor are they at all conclusive. With regard to experiments on immunity in yaws, it is at once evident that the question of identity or difference between yaws and syphilis was paramount in the minds of the investigators. In short, on reviewing the work of these authors, we discover that, while they developed a considerable volume of knowledge bearing on the subject in general, the conclusions they drew from their experiments on animals or on humans were at considerable divergence. One is led to the conclusion that the cause of the confusion is to be found in the experimental methods employed in some of the work. The number of experiments performed is too small to afford a scientific basis for the conclusions drawn. It is likewise seen that similarly definite conclusions were based on negative results, no consideration apparently having been given to the possibility that failure may have been due to the employment of faulty technical arrangement.

The investigations of Neisser⁽²⁰⁾ and his coworkers yield sufficient evidence to show that neither does syphilis immunize against yaws nor yaws against syphilis, when infection and superinfection take place under the conditions under which their experiments were conducted. However, the negative results attained in their efforts to produce superinfection with yaws in framboësic animals require explanation, especially as their account fails to show that the viability and infectivity of the material they used for the superinfection of yaws monkeys were tested by inoculation into control animals. The same objection arises in connection with the work of Levaditi and Nattan-Larrier.⁽¹³⁾ They were not able to produce yaws in syphilitic monkeys. Castellani,⁽⁶⁾ however, proved that framboësic animals can be infected with syphilis. Ashburn and Craig⁽¹⁾ are quoted as having concluded that Philippine monkeys are susceptible to yaws but not to syphilis. It seems quite evident from the foregoing, therefore, that these questions cannot be definitely

answered unless the course of the disease as it occurs in monkeys is thoroughly known, and unless a gradually developing immunity can be made apparent by definitely recognizable and reliable signs. Close attention must be paid to the character of the lesion in animals with a view of discovering in them such modification of the frambœsic manifestations as are known to exist in man. This is because convincing evidence of immunity cannot be considered to be afforded by the phrase "negative take," when at the same time it is clearly apparent that the material used in inoculation has not been tested in control animals and only one attempt at infecting the animal was made. Sellards and Goodpasture⁽²⁹⁾ crystallize the situation in the remark "Before concluding that yaws affords no protection whatever against syphilis, it would be desirable to demonstrate that some degree of immunity had been established to yaws itself before testing the resistance to syphilis." That these two diseases are closely related is admitted with greater or less frankness by all investigators, including the "Dualists." This is evident from such statements as "yaws is no more syphilis than leprosy is tuberculosis," and "the relation of the two diseases can be compared with the relation of tertiana to tropical malaria."

It would seem unnecessary to argue that this problem can be solved by other than experimental means; there are too many disturbing factors. Repeatedly, other origin or etiology has been assigned to lesions in man attributed to yaws. Even when it has been possible to demonstrate spirochætes in these lesions, thus fulfilling the first postulate of Koch, the question inevitably has arisen as to whether the spirochætes were *Treponema pallidum* or *T. pertenue*. Experimentation on man has thrown some light on certain phases of the problem; but, since spontaneous syphilis as well as yaws occurs in human beings, there always will remain a shadow of doubt as to the real etiology of some of the experimentally produced lesions. Moreover, the majority of yaws patients are ambulatory cases, and they present themselves with well-developed lesions, "primary," "secondary," or "tertiary" in type, as the case may be. The opportunity in the clinic to see the beginning of any type of frambœsia is exceedingly rare. With the introduction of salvarsan into the therapy of yaws the possibility of following the cases throughout the entire course of the disease ceased to exist. After the first injection of the drug the skin manifestations heal with such rapidity that the patient deems it no longer necessary to report to the clinic. The same limitations fail in experiments on human volunteers. Sooner or

later the developing yaws reach such dimensions that it is not justifiable to delay treatment any longer and the entire process is terminated at a moment when the scientific interest really begins. Another factor that militates against clinical observations and experimentation on human beings with a view of deciding the etiology of protean lesions of yaws lies in the fact that the greatest variety of these lesions occurs naturally in heavily infested regions where practically everybody has, or has had, yaws. The choice of volunteers thereupon becomes difficult and sometimes impossible. In the face of such extensive infestations it is difficult to ignore the possibility that other skin lesions, having nothing whatever to do with framboesia, may as well occur in a framboesic patient as in one who is not suffering with yaws. In other words, the exclusion of nonspecific lesions by comparison under such conditions offers a difficult as well as a highly important problem. The difficulty of differential diagnosis of protean lesions of yaws in particular becomes far greater if one remembers the great similarity between certain manifestations of yaws and certain manifestations of syphilis. Even though spirochaetes be found in a lesion the possibility of their being *Treponema pallidum* and not *T. pertenue* unfortunately exists. In 1912 Plehn⁽²⁵⁾ arrived at the conclusion that "one can therefore say with regard to differentiation of certain late framboesic from late syphilitic lesion" ¹ that "the possibility of further investigation in the clinical field lacks all grounds." In my judgment it would be beyond reason to demand the fulfillment of Koch's first postulate—the actual demonstration of *Treponema pertenue* in a lesion—as the absolute criterion for its determination as of framboesic origin. If it be borne in mind that under natural conditions lower animals suffer from neither spontaneous syphilis nor spontaneous yaws, it will seem quite as apparent to others as it is to me that the production in these animals of lesions clinically and anatomically characteristic—in short, in main respects identical with those found in man—will afford as convincing proof of the etiology of the lesions as can possibly be produced at the present time. At all events, such a criterion meets the terms of the third postulate of Koch, which requires the experimental production of the disease.

An account of the inoculation experiments on animals lower than monkeys is not included in this short review of the history

¹ The translations of passages quoted from papers in languages other than English are mine.—O. S.

of experimental yaws in animals. The intratesticular inoculation of *Treponema pertenue*, like that of *T. pallidum*, is a valuable laboratory method to secure material in which the treponemas are free from bacterial contamination and to maintain them in that condition, as well as a preliminary step toward obtaining pure cultures of the organism. However, the possibilities of experimentally solving by this procedure some of the dark chapters in our knowledge of human frambœsia are very limited. The testicular tissue is neither the portal of entry nor even the favorite place of localization of *Treponema pertenue*. The experimental possibilities of this method have been practically exhausted by Nichols⁽²¹⁻²³⁾ and by Matsumoto, Ikegami, and Takasaki,⁽¹⁷⁾ so far as frambœsia is concerned. The intratesticular inoculation of *Treponema pertenue*, being an artificially created condition, will not solve such problems in human yaws, as, for instance, the etiology of certain atypical or unique lesions encountered in yaws-infested countries, and it is questionable whether the problem of immunity to yaws in man can be solved by experimentation by means of intratesticular inoculation, as the testicle is positively known not to be affected in human frambœsia. It must be borne in mind that yaws, as far as the human is concerned, is primarily a skin disease, and in the majority of cases remains such, even though what may be called septicæmic distribution takes place. In that respect yaws resembles smallpox so closely that the analogy of those two diseases in their pathogenesis and immunity forces itself upon one's mind despite the fact that the two diseases differ from each other in many other respects. There is no more reason to consider yaws and syphilis identical in every respect just because the causative agents as far as morphology and biology are concerned are almost indistinguishable than there is reason for the assumption that the pathogenesis and immunity of tuberculosis and leprosy must be identical in every respect. As leprosy is primarily a skin disease, so is frambœsia, while tuberculosis affects preferentially the internal organs, an occurrence which is secondary in leprosy. The entire process and pathogenesis and, consequently, immunity in yaws is so complicated, and no doubt so changeable and different in its various stages, that the clinical course of yaws as it occurs in man must be duplicated in an animal before all the varieties and numerous stages in the pathogenesis of the frambœsic infection and therefore in the immunity can be discovered. The confusion and the contradictory and discordant results of the experiments by renowned

investigators of this wide and composite problem, both in animals and in humans, is the best proof of the complicated intricacy of the entire problem.

With the foregoing preamble the concrete consideration of the following problems, which have been attacked in these experiments, will now be given:

1. Does frambæsia tropica in monkeys run a course similar to that in man, or can it be induced to do so by special experimentation?

2. Does immunity to yaws exist in animals infected with yaws, and how does it present itself?

3. Is this immunity, if it exist, permanent, or does it last only during the stage of yaws infection?

Therefore, without having attempted any comparison or cross-experimentation between syphilis and yaws, I have endeavored to extend the knowledge of experimental yaws and its immunity in animals, at least to a point corresponding with the existing knowledge with respect to experimental syphilis and its immunity. Not until the pathogeny and immunity of yaws have been thoroughly investigated will it be possible to see the points in which these two diseases, syphilis and yaws, agree and those in which they differ. Furthermore, if lesions in man suspected to be of frambæsic origin can be duplicated in experimental animals no doubt can remain as to their identical etiology. In this respect the results of my experimentation here reported have surpassed all expectations.

TECHNICAL PART

The impression gained by early experimentators who attempted to transmit yaws to animals, that lower monkeys are not susceptible to this disease, was soon corrected. The possibility of successful transmission of yaws to Philippine monkeys was demonstrated by Ashburn and Craig,⁽¹⁾ and by Strong and Guerrero.² I was an eyewitness of successful inoculations made by E. L. Walker in 1912. As far as could be ascertained all of these workers, with the exception of Ashburn and Craig, made their inoculations exclusively into the eyebrows. Whether or not they were led by the statement of Halberstädter,⁽¹⁰⁾ that anthropoid monkeys are inoculable in all parts of the body, but lower monkeys only in the eyebrows, I cannot say. If this statement of Halberstädter be true it would indicate that *Treponema*

² Oral communication.

pertenue not only has tissue-selective proclivities but also prefers skin tissue of a certain anatomical condition to skin tissue in which this condition is absent. In other words, it would indicate a local, what might be termed anatomical, tissue resistance. On the other hand, it may simply mean that the *Treponema* must be placed in a certain layer of the skin in order to obtain a foothold, and that this is more likely to happen in the skin of certain parts of the body than in that of others. The latter supposition is more likely to be true, since Ashburn and Craig produced a positive yaws lesion on the abdominal skin of a Philippine monkey by the pocket method. In my experiments inoculations were made in various parts of the monkey's body, not with the primary purpose to test the validity of the statement made by Halberstädter,⁽¹⁰⁾ but rather to find the most convenient part of the body of the monkey in which transmission inoculation would invariably take. Another point necessary to decide in these experiments was to find the part of the body where the take and the frambœsic lesion would persist for the longest time or give the greatest yield of treponematous material, so that we should be able to maintain the strains of *Treponema pertenue* economically without having to waste many animals and without the necessity of constant vigilance for fear of losing the strains. Thus the above-mentioned contention of Halberstädter necessarily underwent a test.

TECHNIC OF INOCULATION

After several attempts to devise a suitable method for the transmission of yaws to monkeys, the following procedure was found most reliable and at the same time best for the purpose of clinically studying the development of the lesion.

The choice of material was dependent on the presence in sufficient numbers of *Treponema pertenue* in the lesion from which the inoculum was to be obtained. The oozing lymph from the lesion was therefore examined under the dark field, and when treponemas were found the lesion was considered suitable for the transmission experiment. The yaw material was scraped off with a scalpel and emulsified gently in not more than approximately equal parts of the scrapings and physiological salt solution at room temperature (28° C.). After a thorough emulsion had been made in salt solution another dark-field examination was made to enable us to judge approximately the amount to be injected according to the number of treponemas encountered in one loopful of the emulsion. This emulsion was injected into

the monkeys by means of a small, sterile hypodermic syringe. More than one monkey was injected with the amount of material and, when the injections were concluded, another dark-field examination was made of the remnant of the inoculum to make sure that the treponemas were evenly distributed in the inoculum and that all the injections performed contained approximately the same number of treponemas.

As yaws is primarily an infection of the skin, this part of the work was concerned mainly with inoculations into the skin; and, as the yaws lesion is predominantly located in the superficial layers of the skin and in man the treponemas are found in the same part of the skin in the largest numbers, the inoculations were made intradermally. By this method attempts were made to produce experimental yaws in the areas of tight and tough skin as well as in those portions of the body where the skin is loose and tender. No attempt was made in this study to produce or to study bone lesions. Injections were made into the following regions: The eyebrows, the nose, the breast and the mammæ, the tail, the periumbilical region, the scrotum, the prepuce, the palms of the hands, the lips, the nasal septum, the perianal region, and the labia majora. It may be of interest to note that repeated inoculations by injection or scarification into the nasal and vaginal mucous membrane persistently failed to take.

Intradermal injections were employed in the greatest number of experiments, in preference to scarification or the pocket method of inoculation. In this way, complications of the primary efflorescences arising through mechanical injuries caused by inoculation were largely avoided.

The needle was inserted subcutaneously some distance from the place at which the material actually was to be injected and the point of the needle was led up into the skin so as to perform the intradermal injection. In some experiments scarification and pocket insertion were used also, the particular object being to discover which of these methods would give the highest number of positive takes under otherwise equal conditions.

The results tabulated in Table 1 show that successful inoculations were obtained on the skin of the nose, tail, scalp, scrotum, and eyebrows, while the ears, mamilla, palms of the hands, labia majora, lips, and perianal region, as well as the chest and the abdomen, gave repeatedly negative results. These results naturally do not mean that the skin of those parts of the body where no lesions were produced by intradermal inoculation

or scarification are absolutely immune, and that an initial local lesion could not be produced at all. Metastatic lesions, or extension by continuity of local lesions to these anatomical regions, were observed from time to time. The results, however, show that the highest percentage of takes was obtained by intradermal inoculation in the scrotum and in the eyebrows. It should be further mentioned that the eyebrow lesion is more likely to run a short course and present the dry form of yaws, while the yaws lesion on the skin of the scrotum is very extensive, giving a large amount of material, and as a rule is of longer duration. Furthermore, the yaws lesion on the eyebrows is more exposed to accidental injury than is that on the scrotum.

TABLE 1.—*Showing the results of attempts at inoculation of yaws into the skin of various parts of the body in Philippine monkeys.*

Monkeys used.	Place of inoculation.	Result of inoculation.	
		Positive.	Negative.
4.....	Ears.....	0	4
5.....	Mamilla.....	0	5
4.....	Palms of hands.....	0	4
3.....	Labia majora and perianal region.....	0	3
15.....	Skin of nose.....	5	10
1.....	Tail.....	1	0
2.....	Chest and abdomen.....	0	2
1.....	Scalp.....	1	0
7.....	Scrotum.....	7	0
16.....	Eyebrows.....	14	2
3.....	Septum nasi.....	0	3

EXPERIMENTAL ANIMALS

The animals used in these experiments were common Philippine monkeys, usually termed *Cynomolgus philippinensis* Geoffroy. Most of these animals came from Laguna Province, though a few came from Bataan Province, both of which are near Manila. They were used at random; that is, old, vigorous, young and small, some recently captured, and some that had been kept in captivity for some time. No attempt was made at zoölogical identification. It was noticed that the age or physical condition of the animal bore no relation to susceptibility to yaws. As a matter of fact, some small and young animals gave faint lesions while vigorous and old animals, as it happened, gave the greatest variety of yaws lesions of the longest duration.

STRAINS OF *TREPONEMA PERTENUE*

All the strains of *Treponema pertenue* that were used in these experiments were obtained from patients in the Philippines. The strains were secured by direct inoculation from patient to monkey and maintained by inoculation from monkey to monkey. Text fig. 1, page 229, shows the successive passages. Altogether five strains were secured in this manner, but most of the experiments were conducted and the lesions described herein produced with the strain called by the patient's name "Cadangan." Besides this, several other strains were isolated in the lowlands; that is, in the vicinity of Manila. The mountain strains, called "Kiangnan," for the locality where they were secured, (15) proved of low infectivity as far as monkeys are concerned. The lesions produced in monkeys on first inoculation with these strains were of very short duration and very mild, having healed suddenly in the early second stage of development of local yaws.

The actual number of treponemas necessary to reach the subepidermal layer is very small. We have seen typical framboëtic lesions develop following an inoculation of less than a half cubic centimeter of suspension of framboëtic material in which under dark-field illumination only one or two treponemas could be found in a search of from sixty to one hundred fields. The lesions developed in due time, provided the inoculum was placed intradermally. Indeed, typical lesions were produced by inoculation of yaws material in which a thorough search under the dark field failed to show any treponemas whatsoever.

SUSCEPTIBILITY OF PHILIPPINE MONKEYS TO YAWS

The susceptibility to yaws of the animals used by us is considerable and with a little care no difficulty is experienced in infecting Philippine monkeys with yaws; in the course of these investigations one hundred twenty Philippine monkeys have been successfully inoculated. Most of these animals were inoculated with one and the same strain of yaws from monkey to monkey. No difficulty was experienced in transmitting yaws to these animals for the first time directly from man. Of the seven attempts to transmit yaws from patients with florid yaws to monkeys only one failed. Five patients and seven animals were involved in these experiments of yaws transmission directly from man to animals.

CLINICAL PART

THE INITIAL EXPERIMENTAL FRAMBÆSIC LESION ON THE EYEBROWS OF
PHILIPPINE MONKEYS

Immediately after the intradermal injection of 0.1 to 0.2 cubic centimeter of the inoculum into the eyebrows there is visible a flat, pale elevation which the next day is surrounded by slight œdema. This œdema disappears and there follows a period of lull. About three to five weeks after the injection there appears either a single papule, multiple acuminate papules, or a flat indurated papule, the first stage (Plate 1, fig. 1), which spreads gradually within the area of the eyebrow and presents a lobulated, indurated, raised, oval lesion with unbroken surface (Plate 1, fig. 2). This lesion sometimes measures 1 to 2 centimeters by 0.5 centimeter, is oval, and the coarse hair within the lesion of the eyebrows is preserved while the fine hair usually is missing by the time the lesion has reached these dimensions. Sooner or later there appear on the surface of the lesion erosions and rhagades, either traumatic or spontaneous. These erosions soon become covered with a rather soft, brittle crust of amber color. The coloration is imparted by the lymph which oozes from the fissures. The color of the crust covering the larger, traumatic erosions may be darker as a result of an admixture of blood with the lymph.

When the scabs are removed an oozing, slightly bleeding granulation tissue becomes visible. This lesion represents the second stage of the frambœsic process in monkeys and corresponds to the typical yaw in man.

Later there is noticeable a central flattening, so that the lesion assumes a circinate form, apparently healing in the center and progressing on the periphery. This constitutes the third stage, or "ringworm form." The spreading of the lesion in this stage is simultaneous along the entire margin of the original lesion. At the same time, it progresses as a linear lesion covered with thin, dry scabs. The extension of this lesion is much more rapid toward the forehead than it is toward the eyelid. It therefore assumes a semilunar form the convexity of which is toward the top of the skull. It then descends the bridge of the nose, producing a butterfly effect down the side of the nose where it appears as a linear lesion toward the outer canthus of the corresponding eye. As the lesion spreads it

becomes drier; there is less oozing and it becomes less elevated than it was in the beginning. The tissue reaction at this stage being very mild, the lesion gradually develops to a narrow line of dry scabs. These bear a closer resemblance to circinated psoriasis than they do to ringworm, to which they have frequently been likened. Before the lesion completely disappears it assumes the form of a narrow, flat, circinated line which undergoes a branlike desquamation and exhibits only slight hyperæmia at the base. Both the upper and the lower eyelids almost invariably escape involvement in this spreading frambœsic lesion.

The progress of the lesion usually stops when it has reached the tip of the nose, the lower margin of the zygomatic bone below the eye, and the top of the skull above the eyebrow. In some instances, however, the lesion has entered the nostril and established itself on the internal surface of the ala nasi; that is, on the mucocutaneous border. It tends to persist there longer than on the face as dry, slightly adherent scabs without much reaction in the underlying tissue. It finally disappears completely.

Although the initial local yaw as a rule heals in the manner described above, two more stages in a local yaw are occasionally encountered. In as much as analogous late skin lesions of metastatic experimental yaws occur in animals, they are mentioned here as the fourth and the fifth stage. Not infrequently, after the yaws on the eyebrows and on the bridge of the nose have healed after having spread upward and downward beyond these regions, there remains, for a considerable time, on the eyebrows and the bridge of the nose, a dry desquamation on a rather thickened skin. This may be designated the fourth stage. After this, the skin on the bridge of the nose becomes shiny and, ultimately, irregular pigmented spots appear. These persist, forming the fifth stage (see Plate 17, fig. 1).

The description of the development of the frambœsic lesion as given above is typical of the most extensive primary lesions observed arising, apparently, from a virulent strain of *spirochæta* in single-infected monkeys. We have, however, observed in monkeys injected either with poor inoculum or with strains of apparently low virulence (Kiangnan mountain strains) that the lesion stopped and disappeared without having assumed the second stage described above. In other instances we have seen, the lesion has ceased to progress and healing has taken place before it has reached the upper limits on the skull and face as has been described. In other words, in the case of animals

inoculated for the first time, we have seen instances in which the progress of the lesion has been arrested, regression has taken place, and eventually all evidence of frambœsic infection has disappeared. This phenomenon, it should be noted, may occur at any stage in the development of the initial local lesion.

If the eyebrows on both sides be injected with the same material at the same time the resulting lesions, in either the second or the third stage, ultimately meet and become confluent without any apparent effect of one lesion upon the other, although one lesion may develop earlier than the other.

THE INITIAL EXPERIMENTAL FRAMBÆSIC LESION ON THE SCROTUM
OF PHILIPPINE MONKEYS

In the previous section mention was made of the fact that the initial local lesion spreads from the eyebrows along the scalp down the bridge of the nose to the cheeks but persistently avoids the loose, soft skin of the lids. Many inoculations were made into the scrotum by the pocket method. That is, a piece of tissue with its adherent scabs was implanted in the subcutaneous tissue close to the cutaneous surface. The skin of the scrotum is similar to that of the eyelid in that it is thin and loose. However, the lesion so produced presented a somewhat different picture. A marked and extensive œdema appeared, which was followed by a deep induration at the place where the inoculum was implanted. Ultimately, there developed a superficial lesion that spread out irregularly. The surface was moist and was surrounded by an area of intact skin infiltrated by a rather hard œdema. In some places the margins were slightly undermined; in others they were flat. It is mainly this œdema of the surrounding skin that produces the ulcerlike appearance of the skin lesion. When the œdema is not very pronounced, the true character of the lesion is evident. It is then seen to be an elevated, granulomatous lesion, covered with brownish yellow scabs and surrounded by a slightly elevated reddish zone. The lesions spread without much healing in the center and involved the entire half of the scrotum and sometimes the base of the penis before they started to regress. The healing took place gradually, the regenerated skin dividing the large lesion into numerous small ones which gradually became covered with crust. The deep infiltration persisted.

When the inoculum was injected intradermally into the scrotum by means of a syringe the lesion proceeded similarly, except that the deep induration and the œdema were absent. It began

as a reddish papule, which gradually spread in the way just described (see Plate 2, fig. 1). The main characteristic of the primary lesion in soft skin, such as that of the scrotum, is that it is more extensive and does not show so much tendency to central healing as does the lesion on the eyebrows or on the nose.

THE INCUBATION PERIOD OF EXPERIMENTAL INITIAL LOCAL YAW IN
PHILIPPINE MONKEYS

The incubation period in higher monkeys is given by Halberstädter as from twenty-two to fifty days, in gibbons from thirteen to fourteen days, and in *Macacus* from ninety-one to ninety-six days. Nichols gives the incubation period as twenty-four days; White and Tyzzer give it as sixteen days; Ashburn and Craig, approximately twenty days; Levaditi gives it as between twenty-four and fifty-two days. The initial lesions described above developed in our animals on an average in twenty-six days, the shortest incubation having been seventeen and the longest, fifty-two days.

THE DURATION OF EXPERIMENTAL INITIAL LOCAL YAW IN PHILIPPINE MONKEYS

The duration of the initial local yaw, experimentally produced in monkeys, is subject to great variations. Halberstädter⁽¹⁰⁾ gives a duration of from three to four weeks in lower monkeys, while in the orang-utan the lesion has been observed to last more than three months. White and Tyzzer⁽³²⁾ noted the duration of the lesion for seven weeks, while Ashburn and Craig⁽¹⁾ reported persistence for a period of between ten and eighty-four days. In the case of two monkeys in our series inoculated with the "mountain strains," the duration was very short. The duration of a superciliary lesion in our experiments, provoked by the method given above and with inoculum containing a fair number of treponemas, was on the average eighteen days, while the scrotal lesion lasted twenty days. These figures show the duration of the actual initial yaw; that is, of the second stage.

LOCAL EXACERBATIONS OF INITIAL LOCAL EXPERIMENTAL YAW IN
PHILIPPINE MONKEYS

The periodic exacerbations of apparently stationary or regressing local yaws lesions have been referred to in the literature as local "recidives."³ In our experiments exacerbations were

³ No period of latency intervenes between the original local yaws and the so-called "recidives." Consequently, the term exacerbations seems more appropriate.

noticed in a certain proportion of inoculated monkeys. The local exacerbations occurred not only in the eyebrows but also in the scrotum. A photograph of an unusual and extensive local exacerbation on the eyebrows and scrotum is shown in Plate 3. As a general rule, the local exacerbations are smaller in extent than is the original lesion. They always occur in the skin already affected, usually involving only a part of the area of the original lesion. As a rule, they are located on the margin of the old lesion and spread by continuity, running the same course as a primary yaw. They are rarely confluent, as in the case illustrated where the exacerbation resulted in a lesion much more intensive than the original experimental yaw. They are sometimes multiple when the healing skin has intersected the old lesion into two or more islands. Local exacerbations occurring in an original lesion that is healing in this manner are very misleading to those who are unacquainted with the past history of the lesion, and may be wrongly interpreted as multiple or metastatic lesions (see Plate 4). Local exacerbations never have been seen to occur in the normal skin surrounding the original lesion; therefore, no significance can be attached to them in the consideration of generalized yaws or even regional dissemination. They are, however, significant in the pathogeny of local yaws and characteristic of the nature of the disease, and are analogous to the periodic crops of generalized yaws. The local exacerbations have invariably been found to contain spirochaetes; they must, therefore, be considered as true, active frambœsic processes.

LOCAL OR REGIONAL LYMPHOGENIC METASTATIC YAWS IN PHILIPPINE MONKEYS

Contrary to the local exacerbations these lesions are detached from the area of the skin affected by the spreading initial yaw, from which they are separated by a more or less wide stretch of healthy skin which up to that time has not been involved in the yaws process. They occur, however, in the same part of the animal's body in which the local lesion established itself. They are of different aspect from the polypapillomatous manifestations of typical generalized yaws, being flat, very superficial, dry, spreading, and covered with a crumbling dry scab. They were observed once in our experiments, interestingly and not without significance in a case that exhibited unusually intensive local recidive (Plate 5, fig. 2).

The regional metastatic lesions are an expression, further advanced than the local exacerbations, of the inherent tendency of the frambœsic process to become generalized, and to

achieve this generalization in successive attacks. Their distribution over the skin and their clinical behavior strongly indicate a lymphogenic rather than a hæmatogenic propagation. They are the forerunners of generalized yaws.

Generalized yaws manifestations are claimed to have been produced by Halberstädter⁽²⁰⁾ in an orang-utan and by Castellani⁽⁴⁾ in a lower monkey. From the photograph of the lesion on the abdomen of an orang-utan it is difficult to judge. The photograph shows the entire animal, which makes the lesions proper too small to allow judgment. They may have been of the type under discussion. It is possible, however, that the lesion described by Castellani should be placed in this group of yaws lesions instead of being interpreted as the polypapillomatous stage of generalized frambœsia.

EXPERIMENTAL SUPERINFECTION AND REINFECTION WITH YAWS IN PHILIPPINE MONKEYS

Very little work has been done on superinfection and reinoculation of yaws in monkeys. Whatever experiments are recorded in the literature are mostly reinoculations, made for the purpose of testing the reciprocal immunity between yaws and syphilis. Neisser, Halberstädter, et al.⁽²⁰⁾ interpreted the failure of reinoculation in frambœsic monkeys as being a sign of immunity to yaws. Levaditi and Nattan-Larrier⁽¹³⁾ interpreted their failure to infect syphilitic monkeys with yaws as proof of cross immunity. Ashburn and Craig⁽¹⁾ met with similar failure to reinoculate one Philippine monkey. It is an amazing fact that, notwithstanding there have been clinical observations of spontaneous autoinoculations as well as successful experimental reinoculations in human beings, the contrary doctrine that monkeys are not reinoculable with frambœsia has permeated the literature of yaws for the past twenty years. Instead of more-extensive experimentation having been undertaken, all possible theories have been invented to reconcile the discrepancies between the clinical observations and experiments on man and the findings in animals. This is not to be wondered at because, strange to say, the results of reinoculations of yaws in animals were uniformly negative and, as the experiments were performed at a time when much stress was placed on antibacterial immunity, the antitreponematous immunity was expected to be at once complete and protective. The failures in experimental reinoculation of yaws of twenty years ago and the occurrence of supposedly generalized yaws in anthropoid apes, which was disputed

by Ashburn and Craig,⁽¹⁾ who observed identical lesions in lower monkeys, are used as differential points in the discussions of the dualistic theory of syphilis and frambœsia. As recently as 1912 Plehn⁽²⁵⁾ stated at a meeting of the German Tropical Society that, with regard to animal experiments, "clinical signs of generalization were always absent, either in syphilis or in frambœsia, in lower monkeys."

Baermann and Schüffner⁽²⁾ at the same meeting brought out as a differential point between the two diseases, the statement that "in higher species of apes secondary manifestations of yaws occur, as in syphilis; in lower monkeys, contrary to syphilis, these manifestations have not yet been observed."

The successful inoculation with yaws of Philippine monkeys, by Ashburn and Craig,⁽¹⁾ and their failure to transmit syphilis to these animals is given by Plehn⁽²⁵⁾ as another differential point. He says: "A particular species of monkeys, *Cynomolgus philippinensis*, is susceptible to frambœsia, but not to syphilis."

The periodic exacerbations of experimental yaws in animals which take the form of so-called "local recidives" and local metastases, the periodic crops of general yaws in human subjects, the gradual change of experimental primary yaws in animals from a papule (first stage), into a typical yaw (second stage), then into the ringworm form (third stage) and, finally, into the frambœsidelike, narrow, superficial lesion, coupled with some recent observations on human subjects, lead me to the belief that by superinfection and reinfection of frambœsic animals some of the manifestations of yaws observed in man may be duplicated in at least some of the experimental animals. Thus, it was hoped, the pathogeny as well as the immunity could be studied in animals. Experimentation on animals with respect to yaws has the advantage over observations and experiments on human beings that the problem can be divided into phases, which can be separately studied. In monkeys inoculated for the first time, as a rule, a primary yaw only develops. It runs its course, regresses, and heals without the yaws manifestation becoming generalized. This is of great advantage if one wishes to study immunity in yaws, as immunity may or may not develop as a consequence of initial local yaw. Furthermore, the pathogeny of certain generalized lesions can be studied with the view to discover whether they originate from a typical metastatic yaw or independently. In the attempt to approach the problem of generalized yaws and of immunity in yaws experimentally, observations were first made on numerous monkeys inoculated

for the first time. These observations were continued for a considerable length of time in order that information might be secured which would enable us to formulate one or more criteria for judging the effect of existing or healed yaws on the form of yaws lesions that develop in these animals upon superinfection or reinoculation.

By superinfection as here used is meant the artificial inoculation of viable treponemas into an animal that already has developed experimental yaws. The second inoculation is made at the stage when the yaws lesions, as a consequence of the first inoculation, are still present and either can still be shown to contain treponemas or can be reasonably expected to contain them even though they cannot be found by the methods employed.

Reinfection as used in this paper means the inoculation of viable treponemas into an animal that has gone through certain stages of a yaws infection, and in which the yaws lesions have disappeared as a result of specific treatment.

Furthermore, another object of these experiments was to study the immunity, if such exists, during the course of the artificial infection in monkeys or at the time of spontaneous or therapeutic recovery. Not only was the general immunity tested by infecting **animals that had active or healed yaws in another place than that used for the first inoculation**, but local immunity was tested as well by a second inoculation into healed parts of the skin of the animal over which the original yaws lesion had traversed. The viability of the treponemas in the inoculum was tested simultaneously on normal control monkeys.

I wish to mention again, and to emphasize the point, that up to the time when I began the superinfection experiments there was not a single case among the monkeys inoculated with yaws that would develop yaws lesions which might even be compared with the generalized yaws as observed in man. In that respect the findings of Ashburn and Craig(1) on Philippine monkeys have been fully confirmed. The typical yaws lesion as described above developed invariably at the point of inoculation only and, although the lesion gradually involved the surrounding tissue, it always spread by continuity, no metastatic lesion ever having been noted in other parts of the body. It was only when an extensive yaws lesion began to heal in such a manner that healed areas of skin intersected the original extensive lesion that an appearance was produced which easily might lead a casual observer, unacquainted with the history of

the lesion, to interpret it as a multiple lesion. Local exacerbations in such a lesion may strengthen this false impression, as has already been pointed out.

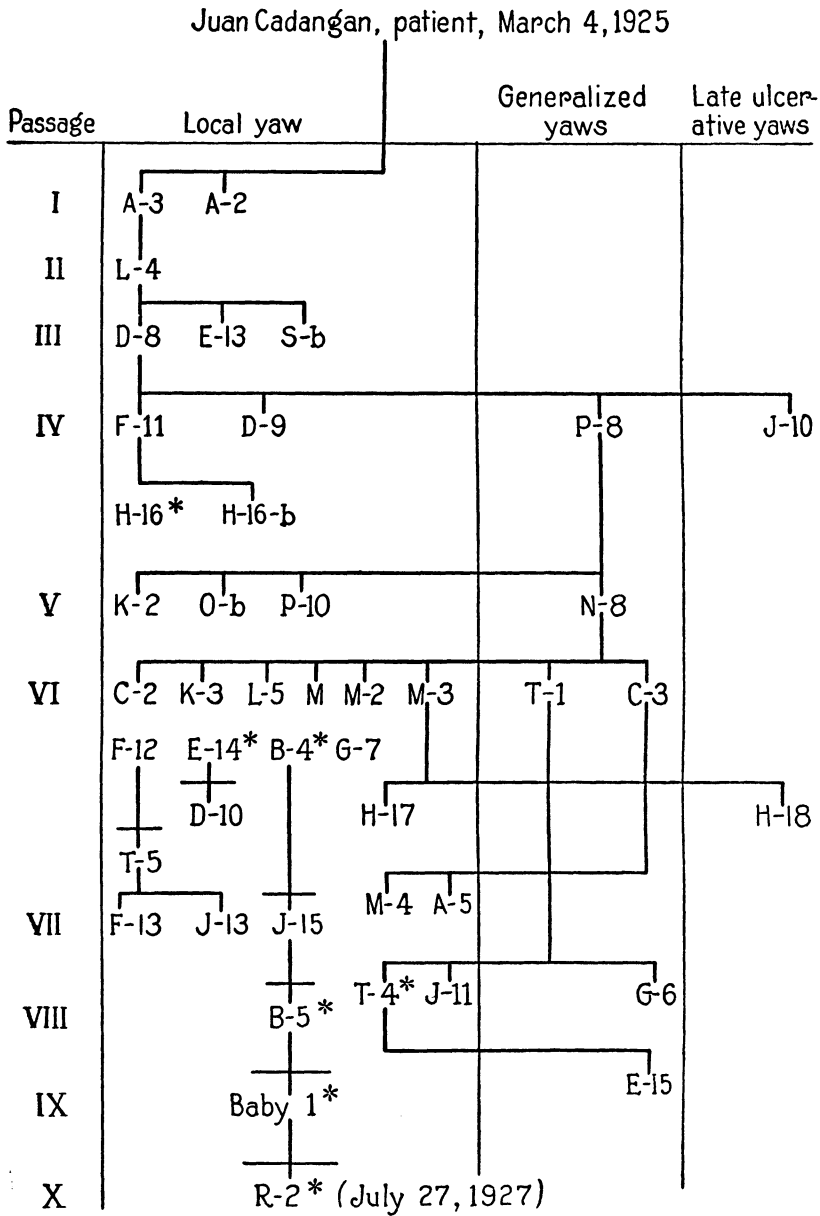


FIG. 1. Showing the results of superinfection and the continuous passage through monkeys of the Juan Cadangan strain of yaws. An asterisk indicates passage through monkeys without superinfection.

The animals were frequently seen scratching the lesions and pulling off the scabs, but in no instance did lesions develop outside of the original point of inoculation. In other words, spontaneous autoinoculation never was observed in these experiments.

It was not until superinfection experiments were started that typical metastatic multiple yaws lesions and late manifestations of yaws appeared in the superinfected animals, clinically and histologically identical with those found in man.

Text fig. 1 summarizes the continuous ten passages of the strain Cadangan through Philippine monkeys. It shows the number of local, generalized, and late ulcerative yaws produced in monkeys with this strain.

GENERALIZED HÆMATOGENIC YAWS, PRODUCED EXPERIMENTALLY IN
PHILIPPINE MONKEYS

From the description of the primary yaw in monkeys it is evident, and should be emphasized, that only the superficial parts of the skin are affected; that, simultaneously with the spreading on the periphery of the lesion, the center heals as a rule completely, leaving the skin to all appearances normal. By repeated superinfection yaws lesions were successfully produced by me in some of the animals that were different in clinical appearance and course from those described as initial yaws. It was, however, nothing unusual to observe a lesion upon second inoculation which in no way differed from the typical initial yaw. The unusual lesions resulting from superinfection were of several kinds. First of all there resulted a diffuse, simultaneous, extensive, and very intensive local lesion over the entire nose and eyebrows or scrotum, with numerous treponemas. This local lesion was identical with the extensive local exacerbation and was followed shortly by a generalized eruption of typical yaws.

Typical metastatic yaws.—The typical metastatic yaw in monkeys commences as a small papule which spreads on all sides and soon becomes covered with more or less pronounced scab, due to the lymph oozing out of the lesion. The lesion is elevated, flat, sharply outlined and, as a rule, oval. It never reaches the size of the primary yaw, but in these experiments it was sometimes observed to assume a considerable size; that is, 0.5 centimeter by 1 centimeter (see Plate 6, fig. 2). When this size is reached the lesion becomes stationary and a central flattening is noticed which extends toward the periphery of the lesion. Thus the lesion heals gradually in toto, leaving a pigmented mark

that can be noticed long after the lesion has healed. Not infrequently, however, the metastatic yaw reaches not more than 0.5 centimeter in diameter and presents a dark crust set upon an elevated basis, which abruptly vanishes into the normal skin. Upon removal of this crust granulating, oozing, papillomatous formation is visible (Plate 6, fig. 1).

When the last-mentioned form of metastatic yaw becomes stationary, when it has reached the size of not more than 0.5 centimeter in diameter, it resembles in every respect the papular form of yaws as known in man.

Not always, however, does the metastatic yaw heal in toto, but frequently, after reaching the full size, it becomes stationary and sends off on the periphery a circular line of dry scabs that progresses on the periphery while the yaw proper is stationary. This manner of propagation brings about a concentric circular effect, as seen in Plate 16, fig. 1.

Ringworm yaws.—The ringworm form of metastatic yaws, frequently encountered in patients, could be studied from the early beginning to its full development and healing. The horse-shoe effect or the semicircular arrangement of the ringworm yaw is due to the semicircular arrangement of multiple initial papules which, in growing, become confluent. This form of yaws experimentally produced in Philippine monkeys is shown in Plate 7. The lesion heals as a rule in toto, becoming gradually flattened and dry, leaving a slight pigmentation or none.

EARLY EVANESCENT FRAMBÆSIDES AND PSORIASIS PALMARIS IN
PHILIPPINE MONKEYS

At least three forms of this early manifestation of yaws (evanescent frambæsidæ) have been noted in the course of these experiments.

The first form, a narrow circle of slightly inflammatory lesions, consisting of a slightly elevated basis and covered with dry scabs, is shown in Plate 8. It begins as a typical papule and spreads out in a circular effect while it is healing in the center. When it has reached a certain dimension it becomes stationary, dries up, and disappears rather rapidly. In as much as treponemas have been found in these efflorescences, it can be considered as a mitigated form of ringworm yaw; but, due to its dermatological resemblance to the frambæside to be described next, it is here classed in the group of frambæsidæ.

The second form is a diffuse desquamative superficial frambæside. It occurred first on the front part of the neck, on the

inner surfaces of the extremities, and then migrated gradually over the entire chest and abdomen. It is illustrated on Plate 13. The individual efflorescences had a typical maplike, circinated shape. There was no reaction at the basis, or only a very slight one. By confluence of the maplike individual efflorescences there resulted an effect not unlike that of dry seborrhœa. No treponemas could be found in this skin lesion, and its affiliation with yaws is based on the ringworm shape of the lesion and on the prompt healing, on neosalvarsan therapy, and by elimination. No such skin affection was noticed on examination of more than two hundred normal Philippine monkeys, either newly secured or kept in captivity for a long time.

The third form of early evanescent frambœsides observed in Philippine monkeys was psoriasis palmaris and psoriasis plantaris. The first of these is shown in Plate 10 and is not quite typical as it is on the border line of the frambœside mentioned as first in these enumerations and contained treponemas. The unusual feature is the grouping of the lesions into a circinated design. The tendency to symmetric distribution was marked but fell short, in as much as the corresponding lesion on the opposite arm appeared on the wrist instead of on the palm. Because of its peculiar grouping, it is not an exact duplication of psoriasis palmaris as this condition is commonly found in man, but resembles it more than any other palmar lesion known to me, particularly when the individual efflorescences are considered rather than the entire lesion. The psoriasis plantaris shown in Plate 12 is typical. No treponemas could be found in this lesion. The initial lesion was noticed to be a flat, elevated macule of dark color, which gradually spread in the periphery until it reached about 0.25 centimeter in diameter. The central portion of the epidermis, which up to that time had remained intact, began to dry and exfoliate. The exfoliation was very superficial and circular, outlined by a paper-white rim. The basis of the exfoliated center was dry, did not ooze, and showed no scab formation. The exfoliation proceeded faster than the spreading of the elevated macule and, after reaching a certain size, the lesion regressed and disappeared while new lesions made their appearance. The successive lesions migrated over the entire sole of the foot, including the pads of the toes. A definite symmetric distribution on the soles of the feet was noticeable.

The affiliation of this type of lesion with yaws is based, first,

on its great resemblance to psoriasis palmaris frambœsica in man and, second, on the prompt healing due to specific treatment.

The typical course of human yaws one is accustomed to read about in textbooks can be best seen in Philippine monkeys from the record of monkey P-8. Following superinfection this monkey developed typical, generalized, metastatic yaws on the wrist, elbows, in the gluteal region, and on the legs. The lesions went through the usual course of the metastatic yaw and in time disappeared, leaving a dark pigmentation. Shortly after the general eruption occurred and while this was still present, there appeared lesions in various parts of the body in crops of rather protean character. During the entire course of the general infection a diffuse alopecia developed in the parietal regions, which gradually became more extensive and involved other parts of the body, particularly the tail. The generalized lesions encountered on the elbows were not unlike psoriasis, except that the silvery scales characteristic of psoriasis were absent and slight oozing rather than bleeding occurred on removal of the scales. When the general metastatic typical yaws started to regress and while still present there appeared circular, ringwormlike, dry efflorescences with a distinctly inflammatory basis in the plicæ cubiti. These symmetric lesions disappeared without a trace and a crop of isolated, circinated, superficial efflorescences with branny desquamation followed. These efflorescences gradually became confluent, simulating dry seborrhœa. While this eruption was still present there appeared on the tail a crop of flat, elevated, papular efflorescences, partly desquamating on the periphery (ichthyosis). The general condition of the animal with generalized yaws became worse, until extreme marasmus set in. Keratoderma plantare of slighter degree than as illustrated in Plate 24, fig. 2, developed toward the end but did not reach the exfoliative stage. Specific therapy brought about prompt disappearance of the lesions, but the animal died. The general characteristic of the successive crops of yaws eruptions in monkeys is that the succeeding crops are more superficial than the preceding ones.

Aside from the typical mother yaw, and the typical metastatic and the ringworm yaws, the skin lesions just described must be considered as frambœsides. In some of them the presence of treponemas was demonstrated by the dark field, in others they could not be found. This brief summary of the generalized yaws

in Philippine monkeys presents the entire picture of so-called "primary," "secondary," and late yaws well known in man. The ulcerative lesions met with in late yaws in man did not develop on one and the same monkey, but they developed in other monkeys that had not gone through a generalized eruption of typical metastatic yaws. Generalized yaws lesions were claimed to have been produced before on the abdominal skin of an orang-utan by Neisser et al.(13) Ashburn and Craig(1) noticed similar extensive yaws lesions in a Philippine monkey. Having compared the photographs of Neisser et al.(13) with the lesions we produced and which we consider as generalized, we agree with Ashburn and Craig(1) who say:

The new lesions were easily demonstrated to be extensions, in direct continuity with preëxisting ones and sound skin was never found separating these lesions while in the active stage. Their progress answered perfectly to the so-called secondary lesions described by Neisser, Baermann, and Halberstädter, but as we have stated, we can not regard them as an evidence of a general infection and therefore as "secondary" in the sense in which the term is used in connection with syphilis.

Ashburn and Craig(1) further state emphatically:

* * * we believe we are justified in asserting that in the species of monkey used [*Cynomolgus philippinensis*] a general eruption of yaws does not occur after experimental inoculation.

These authors evidently do not believe that either their case in a Philippine monkey or that of Neisser et al.(13) in an orang-utan was true general yaws. They, furthermore, express their opinion very reservedly with regard to the experiment of Castellani(3) for they say:

Castellani appears to have secured true secondary lesions situated at a distance from the original papule in his one successful inoculation and in this case a general infection might be supposed to exist.*

These lesions appeared in the face at a short distance from the original initial local yaw. A photograph not being available I am not in a position to pass definite judgment on the lesions produced by Castellani;(3) but, from the description quoted by Ashburn and Craig,(1) I believe that they were local lymphogenic metastatic lesions rather than the so-called "local recidives" and, therefore, similar to my case (Plate 5, fig. 2).

The question whether or not yaws in Philippine monkeys can be induced to run the same clinical course as it does in man finds its answer in this section. All previous experimenters

* Italics mine.—O. S.

agree that the primary efflorescence, or the mother yaw, is so typical that it can be recognized in monkeys as such. Ashburn and Craig(1) state:

All * * * monkeys developed yaws lesions of sufficiently characteristic appearance to permit of diagnosis based on that feature alone. [p. 451.] The lesions [primary] in monkeys do not differ essentially in their morphology from those occurring in the disease in man, * * *. [p. 457.] We believe from their [primary lesions] appearance alone a clinical diagnosis could be made even in the mildest case of infection we have observed, while in the more severe infections * * * the nature of the lesion was apparent at a glance. [p. 460.]

As to the course of the primary lesion in Philippine monkeys, Ashburn and Craig(1) state: "After persisting for varying periods of time the lesions of frambœsia heal in the same manner as those occurring in man." The similarity in development, course, and healing of the experimental initial yaw in monkeys to those in man is generally recognized. Unfortunately, previous experimenters did not succeed in producing any further lesions of yaws in animals. Anyone who has seen the development and course of generalized yaws in monkeys will be impressed by the fact that the typical metastatic yaw, in monkey as in man (Plate 9, fig. 1), is far more characteristic than the initial local yaw, and no one who has seen the multiple, typical, metastatic yaws in man will hesitate to recognize them in animals. There is no doubt that it was the appearance of the metastatic yaw, not that of the mother yaw, that suggested the name frambœsia (raspberry).

The lesions, just discussed, in the superinfected monkeys and in the single-inoculated monkey (see below) are considered metastatic and not accidental autoinoculations, for the following reasons:

1. They were never noticed in animals infected for the first time and in which the infection ran the usual course of the local experimental yaw.

2. They were found exclusively in animals that developed an unusual extensive and intensive local lesion at the place of superinfection, or that showed an unusually extensive and intensive exacerbation (Plate 3 and Plate 5, fig. 1).

3. They did not resemble the initial local yaw but did resemble metastatic generalized yaws in man, and they occurred in successive crops.

4. They were symmetric, and were located topographically in parts of the animal's body where all attempts at artificial

inoculation persistently failed and, strangely enough, seldom if ever occurred in places where local yaws lesions could be produced with ease.

TOPOGRAPHY OF GENERALIZED YAWS

Definite regularity was noticed in the distribution of the metastatic lesions in animals used in these experiments. The early generalized lesions (that is, the typical metastatic yaws and the metastatic ringworm forms), both skin lesions in which treponemas were readily demonstrable, were, briefly speaking, *juxta articular*. The dorsal surface of the wrists, elbows, *placæ cubiti*, ankles, knees, and trochanters were the places of predilection. The lesions were symmetric though not always located on identically corresponding places.

The early evanescent circinated frambœsides migrated in successive crops over the front part of the neck, the chest, the abdomen, and the inner surfaces of the extremities.

SPONTANEOUS GENERALIZATION OF YAWS IN A PHILIPPINE MONKEY FOLLOWING A SINGLE INOCULATION WITH *TREPONEMA PERTENUE*

In the later part of this experimental work⁵ I had the opportunity to observe a spontaneous generalization of yaws infection in a monkey following a single inoculation. This singular case seems to warrant more-detailed description. The sequence of the lesions and the course and development of the spontaneous general infection proved the correctness of the plan conceived with the view to produce general clinical manifestations of yaws in animals by repeated superinfection. It also explains the success attending these experiments, in as much as the course of the natural general infection was a duplication of that which I observed in other animals as a consequence of superinfection. The objection therefore that, under such artificial experimental conditions, the general infection in yaws monkeys may assume a course unnatural with these animals lacks all grounds.

A rather strong male Philippine monkey was inoculated on December 11, 1925, with material containing numerous treponemas. The material was obtained from a metastatic typical yaw in a monkey that had been superinfected. After the incubation period a distinct oozing lesion on the right inner eyebrow and

⁵ The experiments were commenced on August 12, 1924.

a slight swelling on the left eyebrow, as well as a distinct flat papule measuring 0.5 centimeter by 0.25 centimeter, covered with moist scab, developed on the scrotum by January 4, 1926. These three points (that is, both eyebrows and the scrotum) were the places where inoculation was performed. The yaws ran the usual course and nothing out of the ordinary was noticed until February 3, 1926, when an extensive local exacerbation was noticed on the eyebrows, the nose, and the scrotum (see Plate 3). The spreading original lesion on the eyebrows had reached the nostril, as is evident from Plate 4. On March 31, 1926, the lesion shown in Plate 5, fig. 2, was first observed. It was a yaw separated from the original mother yaw by healthy skin, but located in the same part of the animal's body as the mother yaw with the excessive local exacerbation. In a previous section it was mentioned that this lesion was interpreted as a lymphogenic or local metastasis.

On account of the extensive local exacerbation which developed on the eyebrows and the scrotum, and due to the appearance of the local metastases, the monkey was purposely not superinfected and the infection was allowed to run its natural course, in the hope that a spontaneous generalized manifestation of yaws might take place. This hope was realized when, on April 27, 1926, metastatic lesions were observed on the elbows, the dorsal part of the wrist of the right hand, and the palm of the left hand (Plate 10). It will be noticed that the original mother yaw, as a result of the artificial inoculation of the monkey, lasted from January 4 to April 27, 1926; that is, approximately three months and three weeks elapsed before the real general manifestations appeared. The local lesion noticed at the time of the general eruption, however, was the exacerbation and not the original lesion which had regressed and spread by that time as a thin line of dry scabs beyond the area covered by the recidive. This fact confirms the correctness of the idea that led me to adopt the plan of repeated superinfection in monkeys; that is, if the local yaw were to last long enough or could be artificially maintained long enough, a certain percentage of the experimental animals should develop one or the other manifestation of generalized yaws. The extensive local exacerbation in this case took the place of the artificial superinfections by means of which in other animals generalized manifestations were produced.

In as much as the lesions on the eyebrows and nose had reached the margin of the nostrils and all the lesions contained

fairly numerous treponemas, no superinfection was made after the appearance of generalized yaws, so that it might be learned whether or not the lesion on the nose would spontaneously last until the allergic state had been reached, which is responsible for the formation of deep ulcerative lesions; in other words, whether or not spontaneous gangosa would develop in this animal. However, my previous experience with superinfection in monkeys that had gone through generalized yaws led me to expect that the immunity would rise rather rapidly and that the manifestations of general yaws would disappear without having become ulcerative lesions.

During the regular inspection of inoculated monkeys a new crop of lesions in the animal under discussion was noticed on the lower extremities on June 5. On the plantæ the lesions were macular, consisting of irregularly outlined macules, which were slightly elevated, darker in color, and about 0.5 centimeter in diameter. They were located mostly on the soft skin of the instep, on the sole of the foot, and on the terminal pads of the toes. They were symmetric to the extent that the corresponding toes on both feet were similarly affected, as were also the soles of both feet. There was noticeable a very superficial exfoliation. The exfoliated part showed no crust forming and no oozing. There was no thickening of the skin, and the lesions started to regress within a few days and new ones appeared (see Plate 12). Along the lower part of the calf in the vicinity of the ankle lesions were noticed of circinated papular efflorescences with a red basis and topped by silvery scales, not unlike those in lichen planus. The lesion on the left hind extremity was circular and measured 1 centimeter in length, and lower down were two papules of the same character. The main lesion was horse-shoelike in shape, and within the space half surrounded by the lesion were minute papules with a red base and silvery scales (Plate 8). On the right lower extremity in a corresponding place four small papules were noticed at this time, distinct but grouped in a semicircle. They were of the same character as the lesion on the left hind extremity already described. A circinated scaling occurred symmetrically on both forearms on the extensor side, consisting of distinct, small papules, covered with silvery scales. On the left wrist, on the radius side right over the joint of the thumb, was a typical yaw covered with dry crust, measuring 1 centimeter in diameter. The surrounding basis was elevated, reddish, and the crust was solid and dry, rather tenacious, but crumbling when forcibly removed,

and leaving a slightly bleeding and oozing base. From that time on the lesions, both metastatic and local, began to regress. On June 17 the lesions on the face and on the scrotum still contained very numerous active treponemas. The lesions on the soles of the feet had regressed considerably by that time, but some superficial desquamation was still present. The yaws over the wrist had spread out in a circinated effect, and the one on the leg had practically disappeared. By July 12 the face had practically healed. There was a remnant of dry crumbling scabs on the tip of the nose and in the nostrils.

On July 24 a remnant of dry scales was visible on the nose. The entire area previously affected by exacerbated yaw showed pigmented and depigmented spots. The nostrils were perfectly clear. On the scrotum there were still a few small lesions, some of them covered with scab. The entire scrotum was darkly pigmented. There was a very slight desquamation on the left wrist and on the left palm, also on the plantæ pedis. The rest of the metastatic lesions had disappeared, leaving no trace.

On July 30 a few remnants of lesion on the scrotum were noticed. The lesion on the left wrist still persisted as did also the slight desquamation on the plantæ. The face was healed, not only the original lesion, but also the lesion on the left jaw.

On August 6 the lesion on the scrotum was found to be in the same condition as before. On the hands the lesions had practically disappeared except on the palm of the left hand where some scaling was present. The nostrils were clear. Dark-field examination showed fairly numerous treponemas in the lesion on the scrotum.

On August 11 small scabs still persisted on the nose, and there were slight alopecia over the eyebrows and a few scabs drying up on the scrotum. Of the generalized eruption very slight scaling remained on the left palm and on the left wrist, accompanied by alopecia on the elbows. The areas of healed generalized eruption were evident by pigmentation. There was some scaling on the soles of the feet. Treponemas were found in the lesion on the scrotum.

On August 18 a very few small lesions were found on the pigmented scrotum. The face had completely healed. Fairly numerous treponemas were found in the lesion on the scrotum.

On August 30 there was nothing but pigmentation on the face. There were also pigmentation and scars on the scrotum. The arms, the hands, and the tail showed no signs of yaws.

INCUBATION PERIOD AND DURATION OF GENERALIZED FRAMBOESIC PROCESS IN PHILIPPINE MONKEYS

It has been mentioned that the average incubation period of a local yaw from the time of inoculation to the appearance of the lesion recognizable clinically as yaw was, on the average, twenty-six days. Compared with the incubation period of local yaw in artificially inoculated volunteers,⁽³⁰⁾ it can be seen that this agrees with the incubation period in man, which was found to be three and one-half to four weeks upon first inoculation and three and one-half to six weeks upon second inoculation of the same volunteers. If the incubation period of the generalized yaws in our experiments performed on humans is compared with that in experiments on Philippine monkeys it will be found that the interval between the first inoculation and the appearance of generalized yaws in man was between ten and fifteen and one-half weeks. In the monkey that developed spontaneous generalization after a single inoculation the incubation period of the generalized yaws was three months, or twelve weeks. It can be seen, therefore, that the incubation period of both the local and the generalized yaws agree very well with the period found experimentally to exist in humans. In the rest of the monkeys that showed generalization upon superinfection the findings were as follows: The incubation period of the generalized yaws from the first appearance of the local yaw due to the first inoculation up to the appearance of generalized yaws was on the average eleven weeks, four weeks having been the shortest and twelve weeks the longest incubation period found. However, if the incubation period is calculated from the time that extensive local lesions occurred as a result of superinfection, it will be found that this incubation period was on the average three and eighty-five hundredths weeks, two weeks having been the shortest and seven weeks the longest period. Up to this stage the course of generalized yaws agrees very well with the incubation period observed in human volunteers. The duration, however, of the generalized process (that is, the period of time from the first occurrence of the generalized manifestation until complete disappearance of the last lesions) differs from that in humans. The average duration in monkeys is only three months, or twelve weeks. In other words, the duration of the generalized yaws in monkeys is apparently much shorter than the average duration of the generalized yaws in man. It averages in monkeys about as many months as it does years in humans.

MORPHOLOGIC AND CHRONOLOGIC RESEMBLANCE BETWEEN THE DEVELOPMENT, COURSE, AND HEALING OF THE MOTHER YAW AND THE METASTATIC PROCESS OF GENERALIZED YAWS, INCLUDING THE FRAMBÆSIDES, AS OBSERVED IN THE COURSE OF EXPERIMENTAL YAWS IN PHILIPPINE MONKEYS

With the picture of the stages in development, course, and healing of the initial local yaw fixed in mind the interpretation of the polymorphous generalized lesions is not so difficult as one would believe at first when confronted with these lesions, some of them changing so constantly that they well deserve the epithet "protean." The frambœsides and the typical polypapillomatous manifestation, as is the case with the initial local yaw, commence with a more or less pronounced papule (first stage of the mother yaw). The typical metastatic generalized yaw develops, further, into a vigorous healthy yaw (second stage of the mother yaw), without going into the third stage of the course of the initial local yaw; it usually stops there, flattens, and heals in toto, leaving a pigmented trace within the entire area affected. Sometimes, however, it becomes stationary and sends off a narrow line of dry frambœsidelike lesions.

The ringworm yaw follows the same stage of development as a typical local yaw, but it starts as multiple papules arranged in a semicircle. This arrangement of the initial papules is responsible for the horseshoe shape of ringworm yaw, which arrangement is maintained more or less throughout the entire course of the lesion.

The ringwormlike frambœside commences as a papule and develops into a small, flat, rather dry, mitigated yaw which spreads on the periphery presenting, first, a seamlike, circinated design. However, the central healing progresses as fast as does the peripheral spreading and the result is as shown in Plate 8. After it has reached this stage the lesion disappears.

The ringwormlike frambœsides follow, therefore, the first stage (papule), a mitigated second stage of the local yaw, and the ringwormlike third stage of the initial local yaw.

The early evanescent, desquamative, migratory frambœsides (Plate 13) start as hardly perceptible papules (first stage of the initial local yaw) and, omitting the typical yaw and the ringwormlike stage of the local yaw, change immediately into the vanishing lesion of the mother yaw. They appear as the last number in the repertory of general early frambœsides, and because of the pronounced exfoliation they constitute morphologically a transitional stage to the ichthyotic, exfoliative, per-

sistent late frambœsides (compare the fifth and the sixth stage of the mother yaw) of which the keratoderma plantare frambœsicum is a local exaggeration.

The individual stages in the development, course, and healing of the local yaw, as manifested by the morphologic changes of the clinical lesions, are reflected in the various forms of generalized yaws manifestation. It is true that certain generalized yaws lesions designated as late manifestations may occur much earlier in one case than in another, but in a single given case the tendency of the manifold frambœsic lesion is to occur in a certain sequence which follows in a general way the sequence of the changes in the course of the local yaw; that is, the general manifestation begins with the eruption of typical or ringworm yaws. Then follow the ringworm frambœside, the maculo-papulous plantar or palmar frambœside, the superficial desquamative frambœside, the ichthyotic desquamative lesion, and the hyperkeratotic manifestation. As in the local yaw, in the metastatic manifestation the early eruptions are of short duration and either occur in crops or migrate over the skin, while the desquamative and hypertrophic manifestations are more persistent.

LATE YAWS MANIFESTATIONS IN PHILIPPINE MONKEYS

ULCERATIVE FORM OF THE SKIN LESIONS

The ulcerative form of lesions was observed in a limited number of superinfected animals. They had had local yaws lesions for a considerable length of time previous to the superinfection. An illustration of this type of lesion, as it developed at the place of superinfection on the left ala nasi, is given in Plate 17, fig. 1, and on the eyebrow in Plate 22, fig. 1. These lesions represent sharply outlined, rather deep defects. They spread slowly, affecting the entire thickness of the skin. In contrast to early lesions, they showed no tendency to central healing, but ultimately healed from the periphery by scar formation. The oozing so characteristic of early lesions is not so well pronounced and the crust is dark, flat, and dry.

GANGOSA

Gangosa, so-called, is a condition that appears to be peculiar to the inhabitants of tropical countries; its relation to yaws was early recognized by a number of observers.⁽²⁴⁾ That view as to the etiology of the condition has not, however, met with unani-

mous support in the more-recent literature. It has been asserted that, in cases of gangosa, syphilitic and other systemic infections have not been excluded. Others who have studied the problem have reached the conclusion that gangosa is a disease *sui generis*.

Manson-Bahr(16) gives the following definition of gangosa:

Gangosa or destructive ulcerous rhinopharyngitis, which has been regarded by some as a sequel of yaws, generally commences as an ulcer on the soft palate. Slowly spreading it may make a clean sweep of the hard palate, the soft parts, cartilages and bones of the nose, sparing the upper lip, which is left as a bridge across a great chasm, the floor of which is formed by the intact tongue.

As to the etiology Manson-Bahr(16) states:

The lesion has been attributed to leprosy, tuberculosis, syphilis, and yaws. There is *no satisfactory evidence* that it is due to any of these diseases.

Farther on he states:

The cases the Editor has personally observed were associated with tertiary yaws-scars on the other parts of the body. It has been suggested by Leys that gangosa is a disease *sui generis*; there is no conclusive evidence for this at present. On the other hand, it is not a form of buccal leishmaniosis.

Musgrave and Marshall(19) express their opinion with regard to gangosa thus:

* * * we will merely state that we have never seen any lesions of yaws which presented the faintest resemblance to gangosa, although the typical framboesial skin lesions are not uncommon in this region [Philippines]. [p. 398.]

These authors state:

Mink and McLean, * * * Leys * * * satisfied themselves that there is no causal connection between syphilis and gangosa. Mink and McLean also convinced themselves that the disease is independent of yaws. Fordyce and Arnold excluded syphilis from the diagnosis of their case. [p. 399.]

Musgrave and Marshall(19) also think that—

* * * the weight of evidence is in favor of the view that gangosa is a disease independent of syphilis, but we do not regard this as a definitely established fact. [p. 399.]

It will require careful observations on several cases * * * to justify a positive expression of opinion as to the part played by syphilis or yaws in the gangotic process. [p. 400.]

Castellani and Chalmers⁽⁵⁾ state: "It is quite possible that gangosa is really a tertiary manifestation of yaws affecting the palate and nose."

Plehn and Mense⁽⁶⁾ see only two etiologic possibilities of gangosa—syphilis or yaws. The latter seems to them more likely than the former. As late as 1926, according to H. S. Stanus,⁽³¹⁾ "the etiology of this condition remains unsettled."

I have had the good fortune to produce and observe the development of gangosa in Philippine monkeys, animals known to be free in their natural state from yaws or any other similar infection, either hereditary or acquired.

The pathogenesis of one type of gangosa as it developed in the experimental monkeys was as follows: The typical initial local yaw of the eyebrows spread down the nose and cheeks, finally reached the nasal mucous membrane, and spread by continuity directly thereon. At this stage the skin lesion healed and completely disappeared, while the lesion on the nasal mucous membrane persisted. However, the fact that a spreading local yaw lesion has established itself on the mucocutaneous border of the nose is not alone sufficient to produce the mutilating destructive process of the soft parts of the nose as is known to take place in gangosa. The allergic state is necessary for an accomplishment of this destruction. I have repeatedly seen an initial local yaw, in monkeys infected for the first time, descend from the eyebrows over the nose in a butterfly effect and enter the nostrils, where it lingered for some time after the lesion in the skin of the face had healed. Ultimately, however, it healed also without producing any destruction of the nasal structures, leaving, at the worst, only a superficial skin scar that extended to the mucocutaneous border. The slight cicatrization resulting from a termination of the local yaw in a condition of the body organism unfavorable to the development of a mutilating process reminds one of the scars on the upper and lower lips found in healed yaws patients. Such scars, indeed, are not infrequently found in cases of gangosa in man, and indicate that yaws have entered the mucous membrane of the nose directly from the lips of the mouth or from the skin around the nostrils.

In the case of experimental gangosa under discussion, superinfection was performed on the eyebrow. In due time a rather deep, sharply outlined, ulcerating lesion developed on the eyebrows. Simultaneously, the residual lesion on the nasal mucous membrane exacerbated and a mutilating ulcerative lesion

developed on the inside of the nasal cavity, affecting the septum and spreading backward without at first affecting the skin of the nose. As a matter of fact, the perforation of the septum was accomplished long before the ulcerative process had affected the alæ at all (Plate 22, fig. 1). Subsequently the alæ also were included, but up to the end no involvement by the later ulcerative process of the skin surrounding the nose was noticed (Plate 23, fig. 1). The anatomic conditions within the nose, as they existed at the time of the death of the animal, are evident from the photograph (Plate 25, fig. 2).

The other form of gangosa is illustrated in Plate 24, fig. 1. In this case a deep ulcerative lesion developed at the point of superinfection; that is, on the left ala nasi (Plate 17, fig. 1). The destruction progressed directly through the ala nasi and spread inwardly as well as onto the surrounding skin (see Plate 23, fig. 2). Unusually pronounced granulations, filling the nostrils, were found in this case; so exuberant were they that at times the breathing of the animal was rendered difficult. Both of these varieties of gangosa (that is, the nasal and the nasocutaneous) are found in man, and there is no doubt that their pathogenesis is the same as that given above.

A papule or an ulcer on the soft palate is designated as the primary lesion in gangosa, by Manson-Bahr⁽¹⁶⁾ and by Plehn and Mense.⁽⁶⁾ This seems to be the generally accepted view, for Castellani and Chalmers⁽⁵⁾ say: "It appears to begin sometimes as a sore throat or coryza, or as a tubercle on the palate." This assumption necessarily presupposes a metastatic origin of gangosa, because it is hardly conceivable that an initial local yaw would originate on the soft palate. How this conclusion as to the original gangotic lesion, expressed in all handbooks and textbooks in monotonously uniform language, was arrived at was not clear to me at first. I failed to find in the literature any record of clinical observation of the course of development of gangosa, from the very early to the well-pronounced stage, or any experimental evidence concerning gangosa, either in man or in animals, that would support such a contention.

In his classic description of this disease J. Numa Rat⁽²⁴⁾ says that gangosa "often, however, avoids the nares and commences in the soft palate. The ulceration of the tubercle [granuloma] extends thence, destroying the uvule and *velum palati*, and the *septum nasi*."

This does not necessarily mean that the lesion did not commence in the nose. As a matter of fact, our experimental case in monkey J-10 (Plate 22, fig. 1) showed perforation of the entire anterior septum at a time when nostrils and *alæ nasi* were still intact. In spite of the findings that the external nose and the surrounding skin of the face at the time when this photograph was taken were intact, previous records and photographs of the same animal (Plate 15, fig. 1) show that the lesion entered the nose by extension of the frambœsic skin lesion onto the nasal mucous membrane. There is nothing in the summary of the observations on gangosa by Numa Rat⁽²⁴⁾ that is contrary to our conception of the pathogeny of gangosa as given above.

Another reference to the initial lesion of gangosa is that of Leys⁽¹⁴⁾ the author of the technical term rhinopharyngitis mutilans.

Leys says:

CLINICAL SIGNS AND SYMPTOMS

The usual history of a case of this disease is as follows:—The patient, if seen early, as few are, complains of *sore throat*. On examination an *ulcer is seen on the back of the pharynx, on a posterior faucial pillar, or on the free edge of the palate. It is superficial, moveable, covered with a thin, dirty, brownish-grey pellicle of slough. This appears to be the initial lesion. The pellicle breaks down and leaves an ulcer which steadily increases, advancing up the throat into the posterior nares.*⁶

There is nothing particularly characteristic in this description of the initial lesion of gangosa. It may apply to diphtheria just as well as to syphilis. Yaws can be excluded (1) in “those seen regularly one case aged 2 and one aged 4 died, and another 9 carefully observed and treated for several months,” (2) on account of the exclusive location of the lesion on the mucous membrane; (3) and the statement that “none of the three cases of children of 3, 4 and 9 showed any evidence of having had yaws.”

It is difficult to say definitely from what affliction these youngest (therefore earliest) supposedly gangosa cases suffered. The sole survivor of these patients “improved steadily,” but neither the nature of the treatment nor that of the improvement is given. In the absence of individual clinical records, bacteriologic and histologic examination, and autopsy findings, it is safe to say that syphilitic “plaques muqueuses” can be eliminated on account of the youth of the patients.

⁶ Italics mine.—O. S.

The paper of Mink and McLean,(18) appearing in the same year as that of Leys(14) and originating from the same institution and from the same small island, Guam, throws some light on the question.

Mink and McLean(18) give the following early symptoms of gangosa:

SYMPTOMS

Onset.—Only three cases have been observed from the earliest stages of the disease. The majority of patients present themselves for treatment only after mutilation is marked. In the three cases above mentioned the initial symptoms led to a diagnosis of tonsillitis, pharyngitis and laryngitis of mild degree. The patients were between the *ages of 12 and 15 years* and were in good physical condition. *Prostration* was slight or absent. All showed a *slight rise of temperature* and complained of *soreness in the posterior nares and pharynx*, with *stiffness of the muscles of deglutition*. In one case a typical *acute coryza* was present. Inspection at this time showed *mild congestion of tonsils, pillars, soft palate and uvula*. During the first week the general condition was practically unchanged.

Local symptoms:—The throat symptoms became localized, and on the *third day a patch of yellowish-gray membrane* was observed on the *soft palate in the first case, the uvula in the second and the right pillar in the third case*. The membrane was *elevated, thick and extremely tenacious*. On removal the denuded surfaces *bled freely*. Within *twenty-four hours* of the appearance of the membrane the *typical ulceration* was established. On the area covered by the membrane a number of small depressions appeared. The ridges between the depressions and the membrane were rapidly absorbed. The ulcer, now about one-half inch in diameter, had a *punched-out appearance*, with *undermined edges and a deep, uneven floor*, covered with a *yellowish-white very offensive discharge*. It was surrounded by a *zone of inflammation* about one-fourth inch in width. The *depth of the ulcer* rapidly increased until, in the case of the uvula and soft palate, the tissues were perforated by the seventh day. These cases are still under observation.⁷

If there remained the slightest doubt in the mind of the reader that the affliction described in the papers of Leys(14) and of Mink and McLean(18) as initial gangosa was anything but diphtheria (nasopharyngeal), a common form in the Philippines, it will be thoroughly dispelled by the following paragraph in the paper of Mink and McLean:(18)

Fulminating Gangosa:—This type occurs in children under 5 years of age, and all cases seen have been in gangotic families. In some instances two or three children in the same family have been attacked. The sudden onset, extreme prostration, extensive membrane, marked cervical adenitis and rapidly developing toxemia and dyspnea give a picture closely resembling diphtheria. Death occurs from toxemia rather than from dyspnea. The great majority of these cases prove fatal within forty-eight hours.⁷

⁷ Italics mine.—O. S.

It is a pity that, in the absence of laboratory facilities to eliminate diphtheria, antitoxin was not administered. This measure would have decided the etiology of the disease and would have saved the history of medicine the burden of a new term (fulminating gangosa).

There is no intention on our part to deny the fact that gangosa is prevalent in Guam; it always was. In point of fact, the Spanish government of the Philippines saw fit in 1828 to send a commission to the Carolines, of which islands Guam is one, to investigate the question. Two extremes have been pictured by Leys⁽¹⁴⁾ and by Mink and McLean,⁽¹⁸⁾ and a wide gap yawns between them. These authors have painted the vivid and sometimes tragic picture of the initial stage with its high mortality; then they transport us abruptly to their observations on well-developed cases of real gangosa—a disease by which “at no time is the patient’s general health materially affected.” The intervening events do not fall within our vision; we have passed over a gap that cannot be bridged by any reasonable stretch of the imagination.

It is realized that the foregoing may provoke the charge that the criticism of these two papers is unnecessarily extreme; that the simple citation of references would have sufficed; and that there was no need of the lengthy quotations. However, I have criticized and quoted at length for what seem to me good reasons and dare to hope for much in consequence. During a period of twenty years these papers have been quoted as standard references and, in parallelism, for a corresponding period the initial lesion of gangosa has been regarded as an ulcer or membrane on the palate. The textbooks and handbooks have told us this with an offset in the dogmatic statement that yaws processes never occur primarily on mucous membranes. It is my belief that these publications have assumed a heavy responsibility for the regrettable fact that gangosa, during all these years, has not been granted admission into the frambæsia family, where it rightfully belongs and where it was placed by Numa Rat⁽²⁴⁾ before 1891 and by other experienced frambæsiologists since.

It is earnestly hoped that a revision of the question of initial lesion and pathogeny of gangosa be made. More-recent observations on patients seem to give some indication of the correct pathogeny of this condition, and experimental findings on animals points only one way.

Rhinopharyngitis mutilans, the name bestowed by Leys⁽¹⁴⁾ upon this form of yaws, is, as its author admits, a descriptive term, and the name gangosa (Ruis de Villalobos) is preferable. It occurs in the literature since 1828 and no doubt has the priority right. It is a local Spanish name that does not mean muffled voice as noticed in sore throat, diphtheria, or quinsy, but is like the Tagalog name *ngon-ngon*, imitative of the speech of a person with a perforated palate. By remembering the name gangosa, the student of tropical medicine will be reminded that what is meant by that name is not rhinopharyngitis mutilans due to syphilis, lupus, leprosy, cancer, leishmaniosis, or rhinoscleroma, but the condition caused by frambæsia tropica and nothing else. He will, of necessity, by knowing this name, remember the geographic distribution of the disease.

In the light of our experimental researches the only explanation for the claim that the starting point of gangosa is the soft palate would be this: When metastatic yaws establishes itself on the soft palate, it lingers there for some time, as the primary yaw did in our experiments on the mucous membrane of the nose. It persists there until the reactivity of the body becomes favorable for late ulcerative lesions. Initial or metastatic yaws on mucous membranes are not known to exist; but direct spreading of primary or metastatic yaws from the skin across the mucocutaneous border onto the mucous membrane is by no means an uncommon occurrence. This speaks in favor of my contention that the starting point of gangosa is the skin yaw, either initial yaw or late ulcerating yaws lesion, extending directly into the mucous membrane. The initial yaw lingers there for some time after the corresponding early skin lesion has healed and the allergic state of the body organism which is responsible for the deep ulcerating manifestation of yaws has been reached. The late ulcerative yaws lesion of the skin directly penetrates the roof of the nose. The statement of Plehn and Mense, junior,⁽⁶⁾ is at divergence with this contention. These authors claim that frambæsic lesions on the faces of gangotic patients are "eminently rare;" yet they present photographs of eight cases of tertiary yaws, including four of early and advanced gangosa. These photographs are reproduced from the excellent work of Hallenberger.⁽¹¹⁾ Every one of the gangosa cases shows unmistakable manifestations of yaws on the skin of the face, mostly on the skin of the nose. The photograph of an

advanced case (11, fig. 46) of gangosa in man shows a condition practically identical with that in our case, the monkey shown in Plate 24, fig. 1. While two others (11, figs. 4 and 44) are identical with the lesions in the monkey shown in Plate 22, fig. 2, as far as the changes on the nose are concerned.

The paper of Dijke, Bakker, and Hoesen⁽⁷⁾ bears on this question. All of their nine cases of gangosa showed frambœsicc lesions on the face, a good many of them about the nose.

I strongly suspect that the papule or tubercle designated as the initial lesion in 1891 by Numa Rat,⁽²⁴⁾ and mentioned by him as sometimes observed on the palate as a primary gangotic lesion, was really an extension of a much older, if not more intensive, nasal lesion that had remained unnoticed or healed up to that time. That the ulcers on the palate described by Leys⁽¹⁴⁾ and by Mink and McLean⁽¹⁸⁾ had nothing to do with gangosa needs no further discussion.

It is remarkable that this interpretation of the pathogeny of gangosa has been handed down in the literature in a uniformly worded definition in very much the same way as has the erroneous teaching that the primary lesion of yaws is an ulcer. The observations on experimentally produced yaws of Hallenberger⁽¹¹⁾ in Africa, and of Sellards, Lacy, and Schöbl⁽³⁰⁾ in the Philippines, prove that the initial uncomplicated frambœsicc lesion is a yaw and not an ulcer. Naturally, in a clinic, the intact initial mother yaw is rarely seen, and the very earliest stage of gangosa probably never.

I have repeatedly observed that the initial frambœsicc lesion in monkeys enters the mucocutaneous border of the nose (see Plate 15), and remains there for some time after the skin lesions have disappeared. In some of these animals gangosa developed from the residual initial lesion on the nasal mucous membrane upon superinfection. Hallenberger (11, fig. 4) describes and illustrates a similar case in man, where metastatic early yaws of the skin extended to the nasal mucous membrane, and he remarks that he never saw a primary yaws lesion on a mucous membrane. In his observations on yaws of the genitalia he noted that the lesions extended from the skin onto the mucous membrane of the vulva. Hallenberger⁽¹¹⁾ also observed many cases of rhinopharyngitis mutilans among the mountain tribes in Kameroun. All of his cases "have gone thru Mabatta (yaws) and still showed on the outer nose frambœsicc efflorescences which stood in connection with the pathologic process in the inner

nose." According to Hallenberger(11) the cutaneous portion of the overlapping lesion yields more quickly to treatment than does that portion involving the mucous membrane. I have observed the same phenomenon in experimental animals during spontaneous healing. The fact that gangosa has been experimentally produced in animals in more than one instance by direct extension of skin lesions, either early or late, onto the mucous membrane of the nose shows that this mode of pathogeny is the commonest if not the only one.

NODULAR LUPUSLIKE LATE FORMS OF YAWS

In certain instances the experimental initial yaw persists for a long time and migrates over the forehead or scrotum, as the case may be. It does not heal by complete restitution, as is the case in early lesions, but by scars that branch out and spread over the entire affected area. The skin becomes pigmented, thin, and glossy, and over this scarred area islets of flat defects or elevated nodules covered with scabs are scattered. The entire lesion assumes an appearance of lupus vulgaris and simulates very closely late yaws lesions in man that have been designated as lupuslike or late nodular yaws lesions.(9) An illustration of this type of lesion as it occurred on the forehead of a gangotic monkey is given in Plate 22, fig. 1.

LATE PERSISTENT FRAMBOESIDES

KERATODERMA PLANTARE AND ICHTHYOTIC DESQUAMATIVE SKIN LESIONS

In their discussion of the pathogeny of frambœsia Castellani and Chalmers(5) make the following statement:

There appears to be a quarternary stage, as yet little recognized, in which the organism cannot be found, in which, however, it has so chemically sensitized the cells that, upon stimulation by as yet little known agents, lesions appear which seem to be of a para-anaphylactic origin e. g. KERATODERMA.

The callous thickening of the plantar skin as well as the ichthyotic skin lesions found on the dorsum pedis, which were extensively described and illustrated by Baermann(2) in the Dutch Indies, and by Hallenberger(11) in Kameroon, have been associated with frambœsia as its late manifestation. That this condition exists in the Philippines follows from the illustrated publications of P. D. Gutierrez.(9) Their etiologic affiliation to yaws rests on purely clinical grounds. Treponemas have never

been found in those lesions and probably never will be; at any rate, if present at all, the finding alone of one or two treponemas cannot explain the extensive hypertrophic and cornification process. Experimental production of these dermatoses in frambœsical animals is therefore of great significance and proves conclusively their etiology.

The main feature of the keratoderma plantare in monkeys was that the lesions developed very slowly and were of long duration. They consisted in a horny thickening, first of that part of the skin that covers the heel. Later other protuberances of the sole became similarly affected. The cornification of the epidermis was most pronounced on the heel throughout the disease. The callous pads were thickest in the center and gradually, without interruption, vanished into the soft skin of the instep, which at first remained normal. The surface of the callosities was, generally speaking, smooth at first; the diffuse, minute loosening of the most superficial layers of the hypertrophic epidermis was responsible for the slate grayish or whitish color of the surface. These lesions represented from the beginning a purely hypertrophic process, without any inflammatory reaction whatever. Being symmetric and of the same extent on both soles, they were restricted to the plantæ pedum. The palms remained normal throughout.

As the disease progressed the thickening of the affected parts increased, the surface became uneven, and exfoliation supervened in the form of shallow, round defects with exfoliated edges. By confluence, these defects became maplike with a cribrated basis. The affected areas remained stationary, with the exception of the outer plantar margin. The shallow, tough exfoliation was most pronounced at this site, as it was at the margin of the heel. Gradually, the lesion crossed the outer dorsoplantar border and spread over onto the skin of the outer part of the dorsum pedis, and at the same time assumed a change in character. The skin of the dorsum adjacent to the dorsoplantar border and over the metatarsal region clear to the dorsal surface of the toes became ichthyotic. On the parchment-like, slightly scaly skin appeared numerous isolated, circular efflorescences, measuring from 2 to 5 millimeters in diameter. They were elevated, dry, concentric lesions showing very little, if any, marginal exfoliation. The soft skin of the insteps became similarly affected. To all appearances the last-described ichthyotic lesions are identical with those seen on the same part of the body in late frambœsia in man. They are truer

to the illustration of patients given in the literature (for instance, by Baermann,(2) Gutierrez,(9) and others) than are similar but topographically unique late frambœsides on the monkey's tail, though identical in character and nature, due evidently to a similar topographic condition of the skin.

Keratoderma plantare and the peculiar late frambœsic ichthyotic exfoliative skin lesions on the dorsum pedis have been experimentally produced in animals by superinfection with yaws. The etiology of these lesions no longer rests on clinical observations alone, in as much as, in the absence of demonstrable treponemas in these lesions, the only possible proof of their etiology has been given, a proof more valid than the demonstration of occasional treponema could furnish. The pathogenesis of the keratoderma in particular has been explained. This condition does not begin as metastatic yaws modified by the anatomic conditions existing in the sole of the foot, but begins, from the very start, as keratoderma. The keratoderma plantare and the ichthyotic desquamative dermatoses affecting the dorsum pedis are late persisting frambœsides. They are one and the same process, the difference in their clinical manifestation being due to anatomical conditions of the skin of the dorsum pedis different from those on the sole of the foot. The photographs in Plate 23, fig. 2, and Plate 24, fig. 2, picture a well-developed, uncomplicated keratoderma plantare in the monkey. The pus-secreting fissures and ulcers met with in some patients afflicted with this condition are undoubtedly the result of traumatic injuries and consequent invasion of extraneous matter, including bacteria. Interesting is the fact that, as in most cases in man, this disease developed in monkeys on the lower extremities only where, in spite of the use of all four extremities in locomotion, the bulk of the body weight rests. May not the constant pressure bring forth the tendency of yaws toward the hypertrophy and cornification of epidermis, so manifest in other forms of frambœsia, to its maximal expression on the sole of the foot?

As a consequence of specific treatment, the experimental keratoderma plantare healed in reverse order to that in which it developed; so that in a certain stage of regression the early stages of its development were simulated. Within four days after the first intramuscular injection of neosalvarsan the healing, first, of the lesion on the dorsum pedis and on the soft skin of the instep was marked. The hypertrophic and cornification process became limited to the foot pads, and even these gradually regressed on further treatment.

Psoriasis palmaris frambœsica must be strictly differentiated from the condition just described. Whether it occurs on the soles of the feet or on the palms of the hands, the condition known as keratoderma is a late manifestation of yaws. It is a progressive diffuse hypertrophic and cornifying process of the skin with exfoliation. Healing does not occur during the active stage.

Psoriasis palmaris frambœsica, on the other hand, is an early general frambœsic lesion, manifested by flat elevated macules with a slightly inflammatory basis, covered with exfoliating epidermis. It consists of separated lesions of various ages. While some are healing, others make their appearance.

Comparing the experimental palmar and plantar manifestations of yaws in monkeys with the lesions commonly encountered in patients, it must be remembered that there are at least three common plantar and palmar yaws lesions in man. First, is the more or less typical metastatic yaw on the sole of the foot that may be somewhat modified when it reaches the neighborhood of the foot pads; second, there is the fairly common psoriasis palmaris which has little resemblance to the typical yaw, being a macular lesion with a reddish elevated basis and shallow and concentric circular desquamation. There is no oozing and no formation of crust. This form is indistinguishable from psoriasis palmaris syphilitica; the third common manifestation of frambœsia on the palms, but more frequently on the soles of the feet, is the keratoderma. There is still less resemblance between the last-mentioned lesion and the typical yaw, it being a diffuse thickening of the skin with secondary desquamation characterized mostly by cornification of the epidermis, pronounced acanthosis, and very slight inflammatory reaction on the part of the cutis. While the first-mentioned two lesions are coincident with the metastatic crops of typical yaws, the third one is a late manifestation and is persistent.

Either of the three yaws lesions, when located on the sole of the foot, is termed "clavos" by the patients.

The coincidence of the first or the second lesion with the keratoderma may create the impression that the basic lesion of keratoderma is a metastatic yaw more or less modified. Experimental evidence, however, shows that this is not the case. In monkeys that have been kept constantly infected by superinfection I have repeatedly seen keratoderma plantare develop from the very beginning as a hypertrophic, diffuse, persistent

process that responded promptly, even though slowly, to specific treatment with neosalvarsan. On the other hand, the experimental psoriasis palmaris described above was accompanied by a general eruption of typical and ringworm yaws in other parts of the body. Induration and slight desquamation without oozing and without the formation of crusts, was typical of this lesion in monkeys. The process was evanescent and typical of psoriasis frambœsica in man.

Keratoderma plantare was noted in monkeys that had been repeatedly superinfected. Some of these animals had metastatic early yaws lesions, while others failed to develop them. Psoriasis palmaris developed only in animals that presented early generalized yaws.

I have successfully produced the initial local yaw, the typical metastatic, the ringworm form, the papular yaws, the early evanescent, the late persistent frambœsides, nodular or lupuslike forms, and the ulcerative lesions of late yaws, including gangosa, in Philippine monkeys.

NONSPECIFIC MANIFESTATIONS OF YAWS IN PHILIPPINE MONKEYS

In enumerating the various symptoms I wish to mention marasmus, alopecia, hyperpigmentation, leucoderma, and lymphadenitis.

After the animals had been kept infected for a certain length of time the nonspecific changes appeared. General atrophy and more or less pronounced diffuse alopecia were noticeable. These gave the animal a peculiar appearance not unlike that of newborn syphilitic babies (Plate 27, fig. 1).

Although the animals were apparently normal and took food regularly, the marasmus in certain instances progressed. Due to this general condition the mortality of the infected animals was rather high and only a few of them survived more than two years after infection had commenced. The usual post-mortem finding in animals that died in the later part of frambœsic infection was that of general marasmus—that is, absence of fatty tissue, atrophy of the liver and heart, and serous clear transudation into the peritoneum, pleura and, most commonly, into the pericardial sack. The spleen was invariably small and firm and no signs were found of bacterial infection except in one case where, in an extremely marantic monkey, typical pneumonia was found corresponding in every respect to the findings made in our experimental work on pneumonia in Philippine monkeys under natural climatic conditions.(28)

In the description of the initial local yaw mention was made of a temporary loss of hair within the area of the monkey's skin affected by the lesion. As the lesion spreads on the periphery and heals in the center the hair is usually restored. Aside from this local alopecia a generalized alopecia is not infrequently found in animals that have been infected for several months. It begins as a rule in the parietal regions. It is a diffuse, not patchy alopecia, and is symmetric. It is frequently noticed in the face and may affect also the extremities. This happens, not by direct extension of the alopecia from the head over the neck to the arms, but on the extremities it usually commences on the distal ends of the feet and the hands, and spreads upward to about the middle of the forearm. In these places the alopecia is most pronounced and displays particular predilection for the tail. It may, however, to a more or less pronounced degree affect the entire body. This generalized diffuse alopecia is persistent, but the hair is sooner or later restored following specific treatment. This phenomenon of lack of hair was observed before on Philippine monkeys, by Ashburn and Craig.⁽¹⁾ The condition, however, may occur in noninfected marantic monkeys, although not so frequently as in yaws animals.

In their attempt and with the intention to accumulate as many differential points as possible between frambœsia tropica and syphilis, frambœsiologists, particularly those working in Africa, stated that, while alopecia is very common with syphilis, it is unknown to be a symptom of frambœsia. One naturally wonders as to the validity of this statement if one considers the absence of alopecia of any kind among pure Africans. My experiments confirm the observation of Ashburn and Craig⁽¹⁾ and further support the point that, with respect to alopecia, there is no innate difference in the nature of *Treponema pertenue* and *T. pallidum*.

Hyperpigmentation of the skin is one of the characteristics of yaws in monkeys. It is not so pronounced on the eyebrows and face as it is on the other parts of the body. It is a discolorization which is restricted to the area of healed yaws, either local or metastatic, and persists a long time. It is particularly pronounced on the scrotum.

Aside from the hyperpigmentation of the skin hyperpigmentation of the hair was noticed in several instances over the eyebrows and on the skull. When the spreading initial local yaw reached its climax and became stationary there was noticed

a deep black discolorization of the hair outlining the healed lesion as a narrow black line over the eyebrows or on the top of the skull. It persisted for some time after the lesion itself had healed but disappeared ultimately without treatment.

The lack of pigment, or leukoderma, can be best seen in the face round the eyebrows and on the bridge of the nose, where a sharp dividing line naturally separates the pigmented parts of the entire body from the rather whitish skin on the eyelids. In a great many instances this line was found interrupted and leukodermic patches overlapping across the line into the pigmented part of the skin were observed (see Plate 17, fig. 1). The leukodermic patches, as a consequence of yaws lesions, were still more persistent than the hyperpigmentation.

THE RELATION BETWEEN THE TYPE AND CHARACTER OF EXPERIMENTAL YAWS
LESION AND THE NUMBER OF TREPONEMAS ENCOUNTERED THEREIN

The number of treponemas found by the dark field in an experimental yaws lesion is variable. The number of treponemas that will be found on microscopic examination can, however, be safely predicted from the appearance or type of the lesion.

As to the type of the lesion, the general rule is that initial and metastatic lesions contain regularly treponemas in sufficient numbers to be demonstrated easily under the dark field. The late lesions, however, either ulcerative, lupuslike, or nodular, are characterized by the presence of so few treponemas that even a persistent and repeated search fails to detect them.

As for the frambœsides, it has already been mentioned that the search in them for *Treponema pertenue* was futile.

Aside from the type of the lesion, the initial local yaw, the metastatic generalized yaw and the late manifestations of yaws, the character of a local or of a metastatic early yaw indicates with fair constancy the number of spirochætes it can be expected will be found upon microscopic examination of the oozing lymph or of the scrapings from the lesion. The elevated, freely oozing, extensive lesion contains very numerous treponemas, while the feeble, dry lesion contains very few. When the healthy, freely oozing lesion, containing numerous treponemas, reaches the third or fourth stage of development and becomes dry and spreads on the periphery, it shows the presence of but few treponemas, while in the last two stages in the development of a local yaw there are, as a rule, none.

In spite of the apparent absence of treponemas, the scrapings from the lesion may produce a take of typical yaw, but this procedure is not reliable and gives occasional failures of takes upon careful inoculation of normal animals. Care should, therefore, be exercised in the selection of material for reinoculation or superinfection, particularly when a test of resistance or immunity comes into consideration.

Repeatedly a long search for treponemas in lymph glands, for instance, failed to reveal the presence of treponemas under the dark field, while inoculation of the suspension of the entire gland produced in the monkey a typical local lesion in which the treponemas were demonstrated microscopically with ease. Thus, in frambœsia the inoculation is a more reliable procedure than is the microscopic search for treponemas.

TERMINOLOGY OF THE VARIOUS FORMS OF YAWS

The classification of yaws into primary, secondary, and tertiary stages has been made by analogy with the familiar terminology in syphilis. This classification necessarily suggests a certain sequence of appearance of the lesions and even a certain dependency of the secondary lesion on the primary and of the tertiary on the secondary, as well as latency of infection separating the three stages from each other. That this classification is not correct, at least with respect to yaws, has been pointed out in the literature.

In our observations⁽³⁰⁾ on experimental yaws in humans the fact was established by experimentation that the typical initial yaw need not develop at all in man, and yet typical, metastatic, generalized yaws will follow (frambœsia d'embleè). Consequently, the frequent clinical experience, that the primary yaw cannot be discovered by questioning the patient, need not be altogether due to the patient's ignorance. As in man, so in the monkey, there is not necessarily a period of latency between the initial, local lesion and the generalized manifestations of yaws.

As in man, so in monkeys, the initial yaw may and usually does survive the metastatic yaws. On the other hand, I have observed that, following the persistence of the initial lesion produced by superinfection, the animal's organism reached a state in which the subsequent superinfection no longer produced

a typical yaw but, instead, produced a deep, ulcerating, slowly growing lesion that did not heal while active, and never from the center affected the entire thickness of the skin, the subcutaneous tissue, and cartilages, and ultimately healed from the periphery by deep scars; in other words, a lesion usually termed tertiary. Therefore, lesions in these cases of experimental yaws, designated usually as secondary, never took place and the infection in the animal passed from the stage termed as primary directly into the tertiary. It is at once evident from this that the systematic classification of yaws, either in man or in the animal under experimentation, into primary, secondary, and tertiary stages is untenable. I have, indeed, seen in an individual, superinfected animal, the direct transition of the so-called primary lesion into a so-called tertiary lesion, the animal, in the meantime, not having passed through either a stage of latency or through the so-called secondary stage.

Deep, late ulcerative lesions do not develop metastatically as such. They spring from early yaws of long duration. The character of these lesions, so different from the early superficial manifestations, is due to the allergic state of the affected animals or of man. One frequently sees in the literature photographs of lesions of a deep ulcerative character in man, that have been labeled "primary lesion," apparently for the sole reason that they developed at the site of the mother jaw. If the division into primary, secondary, and tertiary stages is to be insisted upon, the paradoxical designation of such a lesion as "primary tertiary" would be justified; primary because original or initial yaw, and tertiary because of its clinical and anatomical character. It, therefore, would be more literal and less misleading to designate the yaws lesions as suggested in the following paragraphs.

The term of the initial lesion as a mother yaw is acceptable in view of the fact that the generalized eruption of typical yaws occurs in man most frequently. The designation of this lesion as an initial local yaw would, however, at the same time, include the initial local yaw that develops without becoming a mother yaw to a subsequent generalized eruption.

The generalized eruption of typical yaws should be designated as a metastatic yaw, typical or atypical.

For the form of superficial metastatic lesions of protean character that develop toward the end or subsequent to the cropping

out of typical yaws, the name of framboesides should be retained. However, besides the designation of early and late framboesides, as is suggested by Hallenberger,⁽¹¹⁾ some should be called evanescent and others persistent framboesides. While the evanescent framboesides, which are in a given case the early ones, still maintain some of the resemblance to certain stages in development of the initial local yaw; the persistent ones, which are the late framboesides, have little if any resemblance to the local, and still less to the metastatic yaw. In them the hyperkeratosis, hyperpigmentation, and depigmentation are pushed into the foreground.

The lesions that are generally termed tertiary should be termed late yaws. Further determination of these lesions should be made by descriptive terms. Whether they produce mutilation or not is largely dependent on the shrinking scars by which they heal, on the extent of the ulceration, or on their topographic location (gangosa).

As a suggestion we would propose the following terms with regard to types of yaws lesions:

1. Local, initial yaw, typical or atypical.
2. Metastatic yaw, regionary or generalized, typical or atypical.
3. Local or metastatic, evanescent or persistent framboesides.
4. Late yaws lesions, ulcerative, nodular, and lupuslike.
5. The bone lesions should be classed by themselves, in as much as they are either early or late, hypertrophic, atrophic, or necrotic. They may affect the periost or the bone itself.

Disregarding the type of the lesion or its genesis, the yaws infection could be divided into two stages; namely, first, the stage during which the patient is susceptible to superinfection after or before he has been cured, and, second, the stage in which the patient cannot be superinfected, either before or after treatment. This division would be of particular importance from the epidemiological standpoint. It may be safely predicted that a person, who has had yaws for about eight months or a year and gone through typical crops of metastatic yaws, will no longer contract yaws, either naturally or experimentally. However, patients that have had yaws for not longer than about a half year may again contract typical yaws infection. The cases of late ulcerative and hypertrophic yaws manifestations represent a protracted first stage.

SEROLOGIC OBSERVATIONS ON EXPERIMENTAL YAWS IN PHILIPPINE MONKEYS⁹

The purpose of the serologic investigation was to ascertain the following points:

Serologic findings in—

- Experimental initial local yaw.
- Experimental generalized yaws.
- Experimental ulcerative forms of yaws.

The influence on serologic findings of—

- Superinfection.
- Treatment.
- Reinoculation.

First of all, an attempt was made to learn the frequency, regularity, and other conditions of Wassermann reaction in the early stage of a noncomplicated initial, local yaw. For this purpose a series of normal monkeys was subjected to the Wassermann reaction, after which the animals were inoculated with yaws. In Tables 2 and 3, showing the development and duration of the Wassermann reaction in singly infected monkeys that developed an initial, local yaw the results of the Wassermann reaction are given. It can be seen that approximately one month after the inoculation and about the time of the appearance of the clinical lesion recognizable as yaw the positive Wassermann reaction appeared. However, at least two out of eight successfully inoculated animals showed persistently negative Wassermann reaction. On the other hand, those animals that failed to take (two monkeys) gave persistently negative Wassermann reaction. It can be further seen from these tables that the duration of the positive reaction in the majority of the cases was very short, only one having persisted distinctly positive for more than three months after inoculation and for two months after the appearance of the clinical lesion. The majority of positive reactions became distinctly weaker and most of them were negative in from five to six weeks after inoculation. This peculiar behavior as to the appearance and short duration of Wassermann reaction in the initial uncomplicated local yaw should not be wondered at, because an analogous condition hardly ever occurs in man, where practically in every case the initial

⁹ Onofre Garcia and Jose Ramirez, of the division of biology and serum laboratory of the Bureau of Science, collaborated in preparing this section, pages 261 to 276.

TABLE 2.—*Showing the development and duration of positive Wassermann reaction in singly infected monkeys that developed initial local yaws.*

[—, complete hemolysis; ±, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; ++++, 100 per cent inhibition; 0, not done; 00, failure to take.]

Designation of monkey.	First inoculation.	First appearance of clinical lesion.	Date and results of successive Wassermann reactions.									
			First examination.	Wassermann reaction.	Second examination.	Wassermann reaction.	Third examination.	Wassermann reaction.	Fourth examination.	Wassermann reaction.	Fifth examination.	Wassermann reaction.
H-20	XI- 8-26	XII- 7-26	XI- 9-26	—	XI- 6-26	—	XII- 2-26	—	XII- 9-26	—	XII-16-26	—
J-15	XI- 5-26	XII- 2-26	do.	—	do.	—	do.	±	do.	+	do.	—
J-16	do.	do.	do.	—	do.	—	do.	±	do.	±	do.	—
A-5	X-22-26	XI-24-26	XI-17-26	—	XII- 2-26	+	do.	±	do.	+	do.	+
N-11	XI-18-26	XII- 2-26	XI-19-26	—	do.	—	do.	0	do.	+	do.	—
M-5	XI-12-26	00	do.	—	do.	—	do.	0	do.	—	do.	—
L-6	XI-15-26	00	do.	—	do.	0	do.	0	do.	—	do.	—
K-6	XI-17-26	XII- 2-26	do.	—	XII- 2-26	±	do.	0	do.	±	do.	—
G-8	XI-16-26	XII-14-26	do.	—	do.	—	do.	0	do.	—	do.	—
E-16	X-27-26	XII- 7-26	do.	—	do.	—	do.	0	do.	+	do.	—

Designation of monkey.	Date and results of successive Wassermann reactions.		Date of superinfection.	Date and results of successive Wassermann reactions.									
	Sixth examination.	Wassermann reaction.		Seventh examination.	Wassermann reaction.	Eighth examination.	Wassermann reaction.	Ninth examination.	Wassermann reaction.	Tenth examination.	Wassermann reaction.	Eleventh examination.	Wassermann reaction.
H-20.....	XII-23-26	—	XII-27-26	I- 5-27	±	I-15-27	±	I-27-27	±	II-15-27	—	II-28-27	±
J-15.....	do.	—	do.	do.	—	do.	±	do.	±	do.	±	do.	—
J-16.....	do.	—	do.	do.	0	do.	0	do.	0	do.	0	do.	0
A-5.....	do.	+	do.	do.	+	do.	±	do.	±	do.	+	do.	+
N-11.....	do.	—	do.	do.	—	do.	—	do.	—	do.	0	do.	0
M-5.....	do.	—	do.	do.	—	do.	—	do.	—	do.	—	do.	—
L-6.....	do.	—	do.	do.	—	do.	—	do.	+	do.	+	do.	—
K-6.....	do.	—	do.	do.	—	do.	—	do.	+	do.	+	do.	—
G-8.....	do.	—	do.	do.	0	do.	0	do.	+	do.	0	do.	0
E-16.....	do.	—	do.	do.	0	do.	0	do.	0	do.	0	do.	0

* These letters and figures indicate month, day, and year; thus, XI-8-26 means November 8, 1926.

yaw is followed either by generalization of the yaws process or by chronic lesion that persists for a long time. In animals, on the contrary, in the majority of cases the local yaw develops, regresses, and heals, by which process the entire infection is terminated. For that reason there are cases where the local lesion during its development and regression, and following its healing, brings about no appreciable change in the serologic behavior of the animal's serum. In order that the reasons for such irregularities as occur in the Wassermann reaction in experimental yaws might be detected, animals in various stages of yaws infection were examined. They represented all of the modifications in the arrangement of infection, superinfection, and reinfection that we applied in our investigation and the results are given in Tables 4 to 8.

The basic table giving the results of the Wassermann test performed on yaws-infected monkeys from time to time has been arranged in Table 4 according to the time factor. It shows in months the time that elapsed between the first inoculation and the date on which the sample of blood was withdrawn from the heart of the infected animal for use in the Wassermann reaction. From this general table one conclusion only can be drawn; that is, the effect of duration of infection upon strength or development of the positive Wassermann reaction. It can be noted that, following the fourth month, strong Wassermann reactions make their appearance.

In Table 7 the data with regard to the result of the Wassermann reaction in yaws-infected monkeys have been arranged, and five factors are considered.

TABLE 3.—*Showing the rapid disappearance of Wassermann reaction in experimental local yaw of short duration (one inoculation) upon spontaneous healing.*

[—, complete hæmolysis; ±, trace of inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition.]

Designation of monkey.	Date of first inoculation.	Date of appearance of lesion.	Date of examination, Wassermann reaction.	Result.	Date of reexamination upon healing.	Result.
T-9	VIII-18-26	IX-6-26	X-6-26	+++	XI-4-26	—
J-14	IX-30-26	X-9-26	do.	±	do.	—
M-4	IX-13-26	do.	do.	±	do.	—
B-4	VIII-6-26	IX-22-26	do.	+++	do.	—
P-11	VI-25-26	VII-16-26	do.	+	do.	—
K-5	IX-23-26	X-9-26	do.	—	do.	—
H-19	IX-29-26	do.	do.	±	do.	—
T-10	VIII-20-26	IX-6-26	do.	+++	do.	—

First is the factor of the number of successive inoculations. This factor was considered with the view to obtaining some information, if possible, as to whether or not the number of successive crops has any influence on the development of the Wassermann reaction in yaws monkeys.

The second factor, column 2, is the number of simultaneous inoculations; that is, in one infection the inoculation was sometimes carried out at one place only, at other times in two places, and at still other times in three places, so that an animal may

TABLE 4.—*Showing the influence of number of takes upon the result of the Wassermann reaction.*

[—, complete hæmolysis; ±, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; +++++, 100 per cent inhibition.]

Monkey No.	Takes.	Wassermann reaction.	Months.	Form of yaws.
O-a.....	0	—	1	Local.
M-2.....	4	+	1	Do.
M-3.....	5	+	1	Do.
T-1.....	1	—	1	Do.
S-b.....	3	±	3	Do.
F-11.....	2	—	3	Do.
O-b.....	2	—	3	Local, mild.
P-9.....	0	—	3	Local.
P-10.....	4	++	3	Do.
D-9.....	1	—	3	Do.
B-3.....	3	++	4	Do.
C-1.....	2	—	4	Ulcerative.
H-16-b.....	2	+++	5	Local intensive exacerbation.
P-8.....	3	++	6	Generalized.
D-8.....	2	±	6	Local.
J-10.....	2	—	6	Ulcerative.
D-9.....	1	++	6	Local.
S-b.....	3	++	6	Do.
B-3.....	3	++++	6	Do.
C-1.....	2	++	6	Ulcerative.
B-1.....	* 3	—	7	Local.
B-2.....	2	+++	7	Do.
O-b.....	2	—	8	Do.
D-8.....	2	±	8	Do.
J-10.....	2	+	8	Ulcerative.
P-8.....	3	++	9	Generalized.
B-1.....	3	+	9	Local.
B-2.....	2	++++	9	Local, extensive.
A-2.....	4	++	9	Local.
A-3.....	2	—	9	Do.
L-4.....	2	++	9	Do.
A-2.....	4	+++	11	Do.
A-3.....	2	+	11	Do.
L-4.....	2	++	11	Do.

a One mild take.

have been infected only once but in one place, in two places, or in three places. This factor is given here regardless of whether the individual inoculation resulted in a take or not.

The third factor is the number of takes; that is, the total number of takes that developed following any number of inoculations made at any number of successive infections.

The fourth factor is the one considered in the first table; that is, the factor of duration of infection.

The fifth factor, in the last column, is the form of the lesion that developed. General classification is made into local typical

TABLE 5.—*Showing the influence of number of infections upon the result of the Wassermann reaction.*

—, complete hæmolysis; $\pm$, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; +++++, 100 per cent inhibition.]

Monkey No.	Infections.	Wassermann reaction.	Months.	Form of yaws.
O-a.....	1	—	1	Local.
M-2.....	1	+	1	Do.
M-3.....	1	+	1	Do.
T-1.....	1	—	1	Do.
S-b.....	1	$\pm$	3	Do.
F-11.....	1	—	3	Do.
O-b.....	2	—	3	Local, mild.
P-9.....	1	—	3	Local.
P-10.....	1	++	3	Do.
D-9.....	1	—	3	Do.
B-3.....	3	++	4	Do.
C-1.....	2	—	4	Ulcerative.
H-16-b.....	1	+++	5	Local intensive exacerbation.
P-8.....	2	++	6	Generalized.
D-8.....	1	$\pm$	6	Local.
J-10.....	2	—	6	Ulcerative.
D-9.....	1	++	6	Local.
S-b.....	2	++	6	Do.
B-3.....	3	++++	6	Do.
C-1.....	2	++	6	Ulcerative.
B-1.....	3	—	7	Local.
B-2.....	3	+++	7	Do.
O-b.....	3	—	8	Do.
D-8.....	1	$\pm$	8	Do.
J-10.....	2	+	8	Ulcerative.
P-8.....	2	++	9	Generalized.
B-1.....	3	+	9	Local.
B-2.....	3	++++	9	Local, extensive.
A-2.....	2	++	9	Local.
A-3.....	2	—	9	Do.
L-4.....	1	++	9	Do.
A-2.....	3	++	11	Do.
A-3.....	2	+	11	Do.
L-4.....	1	++	11	Do.

Monkey No.	Months.										
	1	2	3	4	5	6	7	8	9	10	11
O-a	—		±								
M-2	+										
M-3	+										
T-1	—										
T-9	±										
T-10	±										
A-4	—										
E-15		—									
B-4		±									
J-13		±									
T-4		—									
K-4		—									
S-b			±			++					
F-11			—					—			
O-b			—								
P-9											
P-10			++								
D-9			—			++					
P-11			—								
B-3				++		++++					
C-1				—		++					
H-16-b					+++						
T-3					±						
N-8					++++						
P-8						++			++		
D-8						±					
J-10						—		±			
C-3						++++					
B-1							—		+		
B-2							+++		++++		
A-2									++		+++
A-3									—		+
L-4									++		++

TABLE 7.—Combined table, showing the influence of severity of lesion, duration of infection, repeated inoculations, number of inoculations, number of takes, and type of yaws upon the Wassermann reaction.

[—, complete hæmolysis; ±, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; +++++, 100 per cent inhibition.]

Monkey No.	Successive inoculations.	Individual inoculations.	Positive takes.	Wassermann reaction.	Duration of infection.	Form of yaws.
					Months.	
O-a.....	1	2	0	—	1	Local.
T-1.....	1	3	1	—	1	Do.
A-4.....	1	2	—	—	1	Do.
T-9.....	1	1	1	±	1	Do.
T-10.....	1	2	—	±	1	Do.
M-2.....	1	5	4	+	1	Do.
M-3.....	1	5	5	+	1	Do.
E-15.....	2	2	2	—	2	Do.
B-4.....	1	1	1	±	2	Do.
J-13.....	2	2	2	±	2	Do.
T-4.....	2	2	2	—	2	Do.
K-4.....	1	2	—	—	2	Do.
P-9.....	1	8	0	—	3	Do.
P-11.....	1	1	1	—	3	Do.
D-9.....	1	2	1	—	3	Do.
F-11.....	1	2	2	—	3	Do.
O-b.....	2	2	2	—	3	Do.
S-b.....	1	6	3	±	3	Do.
P-10.....	1	7	4	++	3	Do.
C-1.....	2	2	2	—	4	Ulcerative.
B-3.....	3	7	3	++	4	Local, extensive.
T-3.....	7	7	0	—	5	
H-16-b.....	1	2	2	++++	5	Local, intensive exacerbation.
D-8.....	1	2	2	±	6	Local.
J-10.....	2	2	2	—	6	Ulcerative.
D-9.....	1	2	1	++	6	Local.
S-b.....	2	6	3	++	6	Do.
B-3.....	3	7	3	++++	6	Local, extensive.
C-1.....	2	2	2	++	6	Ulcerative.
C-3.....	2	3	3	++++	6	Generalized.
P-8.....	2	3	3	++	6	Do.
B-1.....	3	3	2	—	7	Local, mild.
B-2.....	3	5	3	++++	7	Local, extensive.
O-b.....	3	5	2	—	8	Local.
D-8.....	1	2	2	±	8	Do.
J-10.....	2	2	2	+	8	Ulcerative.
A-3.....	2	4	2	—	9	Local.
B-1.....	3	3	3	+	9	Do.
L-4.....	1	2	2	++	9	Do.
A-2.....	2	6	4	++	9	Do.
P-8.....	2	3	3	++	9	Generalized.
B-2.....	3	6	2	++++	9	Local, extensive.
A-3.....	2	4	2	+	11	Local.
L-4.....	1	2	2	++	11	Do.
A-2.....	3	8	4	++++	11	Do.

riations in the number of inoculations and the number of takes. There are also variations in the results of the Wassermann reaction. There appeared to be a relation between the strength of the Wassermann reaction and the number of inoculations, and the number of takes. The two frankly positive Wassermann reactions were found in monkeys that had been inoculated in five places and developed four and five takes, respectively. It seems to show that these two factors are significant; but, whether both of them or only one is so, and which one, is not apparent from this group.

TABLE 8.—*Showing the influence of number of inoculations upon the result of the Wassermann reaction.*

[—, complete haemolysis; $\pm$, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; +++++, 100 per cent inhibition.]

Monkey No.	Inoculations.	Wassermann reaction.	Months.	Form of yaws.
O-a.....	2	—	1	Local.
M-2.....	5	+	1	Do.
M-3.....	5	+	1	Do.
T-1.....	3	—	1	Do.
S-b.....	6	$\pm$	3	Do.
F-11.....	2	—	3	Do.
O-b.....	2	—	3	Do.
P-9.....	8	—	3	Do.
P-10.....	7	++	3	Do.
D-9.....	2	—	3	Do.
B-3.....	7	++	4	Do.
C-1.....	2	—	4	Ulcerative.
H-16-b.....	2	+++	5	Local, intensive exacerbation.
P-8.....	3	++	6	Generalized.
D-8.....	2	$\pm$	6	Local.
J-10.....	2	—	6	Ulcerative.
D-9.....	2	++	6	Local.
S-b.....	6	++	6	Do.
B-3.....	7	++++	6	Do.
C-1.....	2	++	6	Ulcerative.
B-1.....	3	—	7	Local.
B-2.....	5	+++	7	Do.
O-b.....	5	—	8	Do.
D-8.....	2	$\pm$	8	Do.
J-10.....	2	+	8	Ulcerative.
P-8.....	3	++	9	Generalized.
B-1.....	3	+	9	Local.
B-2.....	6	++++	9	Local, extensive.
A-2.....	6	++	9	Local.
A-3.....	4	—	9	Do.
L-4.....	2	++	9	Do.
A-2.....	8	+++	11	Do.
A-3.....	4	+	11	Do.
L-4.....	2	++	11	Do.

In the second group, the two-month group, the factors of time and form of lesions are the same. The factors of number of successive infections, the number of inoculations, and the number of takes do not vary considerably, the lowest being one and the highest two. In consequence, the results of the Wassermann reaction do not vary either, there being three negative and two doubtful Wassermann reactions in this group.

In the three-month group the factor of number of successive infections does not vary much, only one animal having had two successive infections; the rest of them were infected only once. The time factor does not vary the number of individual inoculations, however, and the factor of takes varies. The factor of form of yaws is slightly modified in one animal that developed a mild lesion after inoculation. In this group, better than in other groups, the predominance of the factor of takes over that of individual inoculations is apparent. The animal that developed the highest number of takes showed the strongest Wassermann reaction. The next highest number of takes showed plus-minus Wassermann reactions, while the rest of the animals gave negative results. It is significant that animal S-b, which received six individual inoculations and showed three takes, had a doubtful Wassermann reaction, the one that received seven inoculations and developed four takes had a strong reaction, and the animal (P-9) that received eight inoculations but developed no take showed negative Wassermann reaction.

The fourth-month group is very small, yet it will be seen that one animal, which received seven inoculations and developed three takes, had a strong Wassermann reaction, while the other, which developed an ulcerative lesion, was negative. This places the ulcerative lesion in a group with the mild local lesion.

The factor of the form of yaws is emphasized in the next small group, the five-month group. The animal infected once in two places, that developed two takes but an intensive local exacerbation, showed a very strong Wassermann reaction; while another animal, which was inoculated seven times in seven places but had no take at all, gave a negative Wassermann reaction.

In the six-month group all factors involved except that of time are varied. The generalized yaws are shown to have given a strong Wassermann reaction, the ulcerative forms either negative or double plus, and the animals that developed local yaws, after six and seven individual inoculations with three takes, behaved similarly to those with generalized yaws. On

previous occasions the number of individual inoculations showed no influence on the results of the Wassermann reaction, provided they were all negative. In two cases (S-b and B-3), however, the negative takes occurred after a series of three positive takes, and the negative takes as quoted were the immune reactions described before. In such cases, when the organism reacts to the inoculation of *Treponema pertenue*, not by a typical yaw but only by an immune reaction, the body organism sensitized by local lesions that developed on previous inoculation may be stimulated to more intensive formation of the reagin.

In the next small group, the seven-month group, where the factor of time and the number of infections are constant and the number of takes does not vary much, the influence of the reaction that develops in a local yaw seems to be evident, in as much as three mild lesions did not produce a positive Wassermann reaction, while two typical yaws followed by three immune reactions produced in the animal a strong positive Wassermann reaction.

The eight-month group confirms the finding made in previous groups, that the number of individual inoculations is a minor factor.

In the nine-month group it can be seen that the generalized yaws and the local extensive yaws with regard to Wassermann reaction are similar, while of the local yaws one of the strongest reactions was found in an animal (A-2) that developed four takes as a consequence of six individual inoculations. The eleven-month group shows plainly that the number of successive infections has no effect and that the number of inoculations is of secondary consideration but the number of takes significant, in as much as the animal that developed four takes on eight inoculations at three successive infections gave a triple-plus Wassermann reaction; animal L-4, upon one infection and two takes following two inoculations, gave a double-plus Wassermann reaction; while the one (A-3) that on two infections and four inoculations developed two takes showed a single-plus Wassermann reaction.

The findings can be summarized as follows:

Of the five factors considered, the duration of the active lesion, the local reaction of yaw, and the number of the takes are primary factors in the strength of the Wassermann reaction in yaws. The number of successive infections showed no relation to the development or strength of the Wassermann

reaction, and the number of inoculations seems to be a secondary factor that enters only when the animal has previously had a yaws lesion.

The time factor enters, in as much as to a certain degree the Wassermann reaction becomes stronger with the increasing length of duration of active infection.

The form of yaws enters, in as much as the stronger the local reaction on the part of the affected tissues the stronger the Wassermann reaction; the milder the local reaction the weaker the Wassermann reaction.

The number of takes has a decided influence on the strength of the Wassermann reaction. The more takes the stronger the Wassermann reaction. The generalized yaws, the factor of repeated crops being eliminated, as evident from this table, comes under the heading of number of takes. That is, the repeated breaking out of yaws appears to count, in as much as the great number of individual skin lesions that take place in generalized yaws influence the Wassermann reaction in the same way as do numerous local takes.

The ulcerative forms, the so-called "tertiary," fall in with the mild local yaws.

As far as these conditions with regard to Wassermann reaction are known in humans, our results in experimental animals agree with the findings in human yaws; that is, the strongest Wassermann reaction is usually found in early generalized yaws, while the early local or the late so-called "tertiary" yaws give slightly positive or negative reaction. Three major and one minor factor are presented here which are responsible for the development and strength of the Wassermann reaction in yaws. Our understanding of the variations in the serologic findings in framboesic patients in the same stage of the disease is hereby made easier.

Furthermore, the observation of the phenomenon of reappearance of positive Wassermann reaction following reinoculation in resistant persons⁽¹²⁾ who, having been completely cured of yaws, fail to take, is hereby corroborated and amplified by experiments on animals.

THE INFLUENCE OF SUPERINFECTION UPON WASSERMANN REACTION IN EXPERIMENTAL YAWS

The effect of superinfection upon the Wassermann reaction in so far as it influences both the duration of the yaws process in experimental animals and the occurrence of various clinical

forms of yaws in monkeys, has been discussed in the preceding paragraphs. In Table 9 the effect of superinfection upon the Wassermann reaction is evident. The animals, having become negative without treatment with regard to the Wassermann reaction, again became positive within about a month after the first superinfection, and some of them earlier, while those that failed to take on the first inoculation and were reinoculated, having given persistently negative Wassermann, resulted in one strong and one weak Wassermann (monkey L-6 and M-5). The superinfection in these cases was performed during the period of reinoculability and was followed by the development of the typical local lesion. Therefore, it is not surprising that, upon the occurrence of a new lesion, what might be termed an artificially provoked recrudescence of the yaws process, the Wassermann reaction again became positive. In Table 9, however, the results of superinfection in animals that originally gave a positive Wassermann reaction were brought to a negative reaction repeatedly by treatment, and to a positive reaction by repeated superinfection following the treatment are given. The interesting finding is that the recrudescence and the relapses of the Wassermann reaction following superinfection happened during a period of resistance to superinfection; that is, the repeated superinoculations resulted in negative takes, and yet the Wassermann reaction became positive.

Another interesting finding is that during the process of repeated treatments and repeated reinoculations the response of the body organism of the experimental animal, both to treatment and to superinfection, became more and more sluggish with the increase in number of superinfections. As far as the behavior of the Wassermann reaction during the experimental infection is concerned, the following conclusions can be drawn:

1. The Wassermann reaction following an acute, uncomplicated, short-lived initial local yaw is irregular and inconstant, and occurs about the time when the local lesion becomes recognizable as a clinical yaw.

2. The Wassermann reaction is of short duration and for some reasons in certain cases does not become detectable.

3. Strong Wassermann reactions begin to make their appearance after the first infection has lasted or has been maintained for four months or more. The strength of the reaction depends on the number of experimental initial local yaws and on the intensity and extent of the local lesion.

TABLE 9.—*Showing the results of the Wassermann reaction in monkeys that were kept infected with yaws by repeated superinfection. The effect of specific treatment and of unsuccessful reinoculation in the resistant stage of yaws upon the Wassermann reaction is also shown.*

[—, complete hæmolysis; ±, trace of inhibition; +, slight inhibition; ++, about 50 per cent inhibition; +++, about 75 per cent inhibition; +++++, 100 per cent inhibition; 0, not done.]

Monkey No.	Date of first inoculation.	Date of examination, Wassermann reaction.	Result of Wassermann reaction.	Treatment.			Date of examination after treatment, Wassermann reaction.	Result of Wassermann reaction.	Date of reinoculation.	Clinical result of reinoculation.
				Commenced.	Finished.	Number of injections.	Total amount of neosalvarsan, in grams.			
A-2	III-4-25	II-16-26	+++	VI-17-26	VII-12-26	4	0.025	—	VII-21-26	—
A-3	do.	do.	+	do.	do.	4	0.025	—	do.	—
B-2	V-23-25	do.	+++	do.	do.	4	0.025	—	do.	—
B-3	VIII-29-25	do.	+++	do.	do.	4	0.025	—	do.	—
L-4	III-26-25	do.	+++	do.	do.	4	0.025	—	do.	—
O-b	IX-12-25	II-24-26	++	do.	do.	4	0.025	—	do.	—
D-9	VIII-29-25	II-25-26	—	do.	do.	4	0.025	—	do.	—
H-16-b	VII-30-25	II-18-26	++	do.	do.	4	0.025	—	do.	—
Positive controls.		do.	+++	do.	do.	4	0.025	++++	do.	—

Monkey No.	Date of Wassermann reaction.	Result of Wassermann reaction.	Treatment.				Date of examination after treatment, Wassermann reaction.	Result of Wassermann reaction.	Date of reinoculation.	Clinical result of reinoculation.	Date of Wassermann reaction.	Result of Wassermann reaction.
			Commenced.	Finished.	Number of injections.	Total amount of neo-salvarsan, in grams.						
A-2	0	0	0	0	0	0	0	0	0	—	XI-26-26	0
A-3	IX-22-26	++	IX-27-26	X-26-26	6	0.03	XI-8-26	—	XI-8-26	—	do.	±
B-2	do.	±	do.	do.	6	0.03	do.	+	do.	—	do.	±
B-3	do.	+++	do.	do.	6	0.03	do.	—	do.	—	do.	—
L-4	VIII-26-26	±	do.	do.	6	0.03	do.	—	do.	—	do.	0
O-b	XI-22-26	±	do.	do.	6	0.03	do.	±	do.	—	do.	—
D-9	do.	--	do.	do.	6	0.03	do.	—	do.	—	do.	—
H-16-b	VIII-26-25	±	0	0	0	0	0	0	0	0	0	0
Positive controls		+++						+++				+++

4. Generalized yaws give a strong Wassermann reaction, such as the intensive or multiple local lesion.

5. Late ulcerative lesions (*gangosa*) give an indefinite, low-grade Wassermann reaction, similar to the finding in a feeble initial local yaw.

6. Upon spontaneous disappearance due to healing of the local yaw and following successful superinfection the Wassermann reaction again becomes positive.

7. Following specific treatment the Wassermann reaction becomes negative rather abruptly in a case of experimental yaws of short duration, and rather slowly in one of longer duration.

8. Unsuccessful superinfection with viable *treponemas* performed in the resistant stage of yaws has as a consequence a reappearance of the Wassermann reaction. When this process of alternating infection and treatment is continued for a long period of time, the promptness of disappearance of the Wassermann reaction after treatment and its reappearance after reinoculation are considerably decreased, and a stage is reached at times in which a low-grade Wassermann reaction persists practically unchanged by either of the two procedures mentioned.

PATHOLOGY OF EXPERIMENTAL YAWS IN PHILIPPINE MONKEYS

It is not intended to present in this section a thorough study of the pathology of experimental yaws. It was necessary, however, to study the histopathology of the lesions experimentally produced in the infected animals, as a confirmation of our observations and diagnosis of the clinical manifestations of yaws in experimental animals.

The description of the histopathology of the yaws lesions in man, as given in the literature by different authors, varies somewhat, apparently due to the difference in the age of the lesion examined. The most concise summary of the histopathology of *frambœsia* I found in the literature is that of Aldo Castellani and the late Albert J. Chalmers.⁽⁵⁾

The striking features in the histopathology of yaws are—

1. The cellular infiltration of the epidermis, which is responsible for the fundamental initial lesion of all early yaws manifestations; that is, the papule.

2. The cellular infiltration and œdema of the cutis, which is responsible for the elevation of the lesion above the surface of the surrounding skin and for the oozing of the lymph out of the lesions and the consequent formation of the crust.

3. The thickening of the epidermis and the downgrowth of the epithelial cells into the cutis, which is responsible for the papillomatous appearance of the early lesions.

4. The cornification and exfoliation of the superficial layers of the epidermis.

5. The excess or the lack of pigment.

While in the early lesions the first-mentioned three features are predominant, the later frambœsides mostly show the thickening of the epidermis, cornification, and exfoliation. The acanthosis is about the most constant phenomenon in practically all early or late yaws, and is found in lesions, on the margin at least, of the late, ulcerative deep type, where the granulation tissue and cellular infiltration are the most-striking features.

In as much as the pathology of early and late yaws lesions has been repeatedly studied by various investigators, we shall not go into the details of the description of these lesions. Some glimpses into the histopathology of experimental yaws are afforded in the attached plates and in their respective explanations. It is, however, not out of place to mention the pathology of experimental gangosa, as it is believed that this phase has not been studied very exhaustively. The contribution is not an exhaustive report on the histopathology of gangosa, but several new points can be presented; they are of importance in the interpretation of the pathogeny of this peculiar condition. It has been noticed at the clinical examinations made during the development and course of experimental gangosa that the process affects a very extensive area of the mucous membrane, far greater than the area which actually undergoes the real ulceration in any stage of the development and course of the condition. This clinical observation on experimental gangosa has been confirmed at autopsy on gangotic animals performed with a view of obtaining some information with regard to the pathogeny of gangosa. It was further confirmed by histopathologic findings. These findings will explain the considerable variation in topography of gangotic ulceration in human patients who present themselves at a stage of full development or at a more or less advanced stage of this condition. The nose, the soft palate, and the larynx have been clinically observed to exhibit an ulcerative process and, because of the location of this ulceration, these various parts of the upper respiratory system were claimed to be the original seat of the initial gangotic lesion. My observations on experimental gangosa led me

to believe that there are only two ways in which the gangotic process begins and, consequently, two forms of this condition can be observed in experimental animals.

In view of these observations on animals the conclusion can be drawn that gangosa in human patients, in whom the gradual development could probably never have been followed from the very beginning to the well-developed stage, should be divided into two forms, the pathogenesis of which is similar to that in animals. That the early yaws lesion enters the nostril and the nasal mucous membrane has been observed repeatedly, as mentioned above. It has also been observed that the skin lesion, either spontaneously or due to therapy, disappears first while the nasal lesion persists. Histopathologic study explains the mode of spreading of early yaw lesions on the mucous membrane, not only of the mucocutaneous border (that is, onto stratified epithelium), but also on the mucous membrane covered with high cubic or cylindric epithelium. The early yaws lesion propagates itself in a similar manner on the mucous membrane as it does on the skin; that is, in the most superficial layer of the mucous membrane (in the epithelium) which gradually undergoes necrosis and, consequently, the mucous membrane becomes inflamed, showing oedema and cellular infiltration (Plate 29, fig. 2). Not all of the area of the inner lining of the nasal cavity affected necessarily undergoes ulceration, and it is only in certain places that offer favorable anatomic conditions that the ulceration ultimately develops. From our experiments it is clearly evident that the process may have trespassed, with or without partial healing, a considerable area of the inner lining of the nose before the allergic state of the entire body, which is responsible for the ulceration, was reached. It can be easily understood, therefore, that the frambœsic process may reach the soft palate and even the larynx before the allergic condition sets in, and then the location of the most intensive ulceration is by no means necessarily the initial lesion of gangosa. The ulceration, therefore, may take place in sections of the upper respiratory system, between the nostrils throughout the nose, pharynx, and larynx. The finished product of this process, which is the ulceration, may be considered clinically far more important than the initial lesion, and the fact that patients usually do not present themselves at the clinic until this ulceration has been accomplished is responsible for the faulty interpretation of pathogeny of gangosa as given in the past literature. It is no more necessary that the most-

advanced lesion in gangosa is the primary lesion than it is necessary to consider great metastases of cancer in the liver as an initial lesion and to disregard the comparatively smaller and at first sight less-significant cancerous ulcer of the pylorus. The second form of gangosa is the late ulcerative skin lesion located in the neighborhood of the nose, which spreads by continuity through the roof of the nose (Plate 17, fig. 1).

STUDY OF IMMUNITY TO YAWS, BASED ON EXPERIMENTAL EVIDENCE
IN PHILIPPINE MONKEYS

INTRODUCTION

One might judge the existence of immunity in animals infected with yaws, first, by percentage of positive takes upon superinoculation; second, by duration of the incubation; third, by duration of the lesion; fourth, by the character of the lesion that develops on superinoculation or reinoculation. From the records of normal monkeys inoculated with yaws material it is evident that the percentage of takes, unless inoculation be repeated, may be misleading in judging the immunity, in as much as 100 per cent of takes would not always result upon one attempt at inoculation. There are, furthermore, certain variations in the incubation period and great differences in the duration of the lesion in the individual animals. This fact cannot be explained as due to differences in the inoculum, because the same monkey inoculated in symmetric places of the body with the same amount of the same inoculum showed considerable variations, both in the incubation and in the duration of the corresponding lesions. As a general rule and on the average, the florid stage of the lesions in soft parts of the skin, such as the scrotum, lasted longer than that induced by artificial inoculations in other parts of the body. However, we have repeatedly seen, in monkeys inoculated for the first time, as mentioned before, that the lesion stopped and regressed in any of the stages of development of the initial yaw. It follows necessarily that, no matter how much they may be influenced by immunity or relative resistance, neither the duration of the incubation period and of the lesion nor the rapid regression of the lesion alone can be safely taken as a criterion for judging the immunity to yaws of monkeys; they are uncontrollable factors, from the experimental point of view. The type of the lesion, however, if its character be taken into consideration, appears to be significant and is as reliable as can be expected.

INTERPRETATION OF RESULTS OF SUPERINFECTION IN YAWS ANIMALS AS A TEST FOR IMMUNITY

In order to prevent the interference of errors in inoculation due to technical or other reasons, the following precautions were adopted.

Superinoculation and reinoculation of yaws animals were performed as described in the beginning of this paper; that is, by intradermal injection. In a very few instances the first attempt at inoculation resulted negative while a subsequent inoculation gave positive results. This happened a few times in the early period of our experimentation, but not in the latter part of the period over which these experiments extended. It is quite possible that the few early failures were due to imperfect technic, but there is an indication of definite adaptation to the monkey's organism of the strain experimented with, in as much as, after the strain had been passed through monkeys for sixteen months, spontaneous generalization after a single inoculation occurred. At the time when the bulk of the superinfection experiments were performed, no failures of takes were noticed. Nevertheless, to assure myself that the material used for superinoculation contained viable and infective treponemas, at least one control (more frequently two) was inoculated simultaneously and with the same material with which a given group of yaws monkeys had been superinfected. Besides this precaution, and in spite of the fact that control normal animals developed the typical yaw, animals that were superinfected and in which the superinfection failed to take were again subjected to superinoculation after a period of one month or more, which time was considered sufficient for the development of the lesion, in view of the fact that we had previously found in a series of monkeys that the incubation period rarely exceeded four weeks. Aside from this double precaution, a safe criterion was used for recording the results of the superinoculation as negative. It was noticed that immune animals superinfected in the early part of the resistant stage invariably presented what is referred to in this paper as specific swelling. As mentioned above, in the description of the development of the initial yaw, the oedematous swelling that persisted for twenty-four hours following the intradermal injection of not more than 0.5 cubic centimeter of inoculum disappeared within a day and there was a lull at the place of inoculation for about twenty-six days, when the lesion started to develop. The specific swelling which may be referred to as immune reaction, due to its resemblance

to the positive luetin reaction in syphilis, developed in immune animals rather early; that is, within a few days after injection and apart from the initial traumatic oedema. Size and symptoms increased rapidly and disappeared quite as rapidly. This reaction as suggested by the term here used, "specific swelling," consisted of noninflammatory oedema, so that it could not be interpreted as a reaction due to the bacteria admixed with the inoculum. Sometimes slight necrosis was noticed. Furthermore, the normal control animals inoculated simultaneously and with the same inoculum did not exhibit such reaction, a fact which further corroborates my contention that this reaction was due to *Treponema pertenue* and not to bacteria present in the inoculum. With this in mind all of the tables must be interpreted.

The appearance of late ulcerative frambœsies shows a condition of body organism having a tendency to localize the yaws process and to keep it from further spreading. That this is due to the state of the superinfected organism and not to the change in the strain of the treponemas is shown by the fact that these lesions developed only in infected animals, while fresh, normal control animals, inoculated at the same time with the same inoculum, developed the typical initial yaw. We have therefore two manifestations of the allergic state following repeated successful inoculation with yaws material. The consequence of the first allergic state is an extensive lesion resembling the initial yaw but far more extensive and intensive, containing treponemata in enormous numbers and followed by generalized yaws; the second allergic state is responsible for the development of ulcerative lesions such as one meets with in late, or so-called "tertiary," yaws in man. The last-mentioned condition indicates an immunity which, while not strong enough completely to suppress the development of the lesion, localizes it, and the tissues react by excessive granulation; at the same time the treponemas are kept at bay.

From the findings in superinfected animals one can reconstruct the pathogenesis and immunity of yaws in man. The description of the incubation period, the course of the initial yaw, the generalized yaws, the frambœsies, and the late forms in monkeys leaves no doubt that, under some circumstances, the disease runs the same course in monkeys as it does in man. The primary yaw develops and runs the course as described above. Superinfection in spontaneous yaws of man from within, in experimental animals from without, under favorable aller-

gic conditions of body organism, produces a generalization, and crops of yaws appear. We have noticed that in superinfected monkeys extensive, local yaws developed at times, as a consequence of superinfection, far more extensively and intensively than did the first yaws lesion. This seems to indicate clearly that a state of greater susceptibility was the consequence of the previous inoculation at the time of the following superinfection. Indeed, as mentioned before, this allergic state was suggested by the fact that local exacerbations and local metastases occurred without superinfection, in one monkey inoculated for the first time, that were of greater intensity than the original lesion (Plate 5, fig. 1).

In other monkeys the result of repeated superinfection was a development of lesions identical with those encountered in humans in the late stage of yaws; that is, deep, ulcerative, granulating, slowly developing (not healing) lesions. This again indicates an allergic state of the entire body in the late period of yaws, because the mutilating lesion developed not only at the place of superinoculation, but also in places remote from the point of superinoculation, as an exacerbation of the vanishing original frambœsic process.

One cannot avoid the impression that in generalized yaws the increasing immunity is responsible for the gradual restriction of the successive early metastatic lesions to more and more superficial layers of the skin; that is, for the gradual change from crops of typical yaws to crops of superficial, evanescent, early frambœsides. This impression is supported by the fact that yaws monkeys cannot be superinfected when the cropping out of yaws has ceased, although the general manifestations of yaws present at the time of superinoculation may last a considerable time after the unsuccessful superinoculation.

From the observations made on the development of the resistance to superinoculation and reinoculation as well as on the healing of the lesions in monkeys, one can draw certain conclusions with regard to the mechanism of the immunity to yaws.

Even though it may be possible to produce immune sera by artificial immunization of laboratory animals with *Treponema pertenue*, there is no evidence of humoral immunity to yaws in man or in monkeys.

Against humoral immunity being responsible for the resistance to superinfection speaks, first of all, the common observation that monkeys become resistant to superinoculation long before the already existing early lesions heal. These lesions

are not secluded from the general system of circulation of the blood and the lymph, as the profuse oozing and the bleeding of their surfaces clearly indicate.

In not less than six instances we failed to observe any effect whatsoever upon the yaws lesions of animals during the susceptible stage of a direct injection into the lesions of blood serum collected from resistant monkeys that had gone through a generalized yaws infection. This confirms the observation of Sellards and Goodpasture⁽²⁹⁾ made on human yaws.

When superinfections are continued on the same animals, sooner or later a stage is reached in which the inoculated treponemas, although proved to be virulent and viable in normal control animals, fail to produce lesions recognizable as yaws. The state of nonreactivity on the part of the body organism toward incorporation of *Treponema pertenue* was more nearly complete and was reached much more suddenly in those animals that went through generalized early yaws than was the case with the animals that upon superinfection developed deep ulcerative lesions or a local yaw only.

The development of complete and protective immunity is very slow, however, and the fact that framboesides or late lesions develop is a sign of partial immunity, in the broad sense of the word. Consequently, the difference in susceptibility to generalized or late ulcerative yaws of the human organism and that of monkeys lies in the quickness and promptness with which the human body organism responds to the infection by one or the other of the two allergic conditions. The monkey's body organism is more sluggish in this respect, but can be stimulated by artificial superinfection.

With regard to the results of superinfection three types of conditions were observed, namely:

Type A.—Animals inoculated for the first time developed typical, initial, local yaw which ran its course without exacerbations and healed in a relatively short time. The second and even the following inoculations of the same animals resulted in the development of a lesion identical with that upon first inoculation or with that in inoculated normal control animals. Continued superinfections produced local yaws lesions of mild degree and, ultimately, only a specific swelling which rapidly disappeared, or no lesion at all. Control animals inoculated at the same time with the same inoculum gave typical takes.

Type B.—Animals inoculated for the first time developed typical initial local yaw, which ran its course without exacer-

bation. About the time when this lesion was vanishing and on the verge of healing the superinoculation was made. The second inoculation resulted in a lesion identical in character with lesions obtained in normal control animals, but was far more extensive and intensive. In the case of spontaneous generalization of local experimental yaw, an extensive local exacerbation took the place of superinoculation. A general eruption of typical metastatic yaws of early evanescent frambœsides and late persistent frambœsides followed in these animals. When crops of general yaws lesions no longer occurred, repeated inoculations were made which resulted in a specific swelling at the point of injection, topped with a noncharacteristic scab, or no lesion at all. No treponemas were found in the last-mentioned lesions. Normal control animals inoculated at the same time with the same material developed typical initial local yaw.

Type C.—Animals in which inoculation resulted in local lesions of long standing with occasional mild local exacerbation, and in which the yaws process was further kept alive by repeated superinoculation, did not develop generalized metastatic eruptions of typical early yaws or early frambœsides, but developed in due time late persistent frambœsides (keratoderma plantare), gave repeatedly positive though not typical takes, and sooner or later the inoculation resulted in a deep ulcerative lesion, slowly spreading, not healing while active, and when healing took place it was from the periphery of the lesion. Very few treponemas were found in these lesions. Some of these animals developed gangosa as a result of such lesion in the vicinity of the nose, while others developed gangosa from a residual lesion inside of the nose upon reinoculation on the eyebrows. These animals while the ulcerative process was still progressing took repeatedly, but when the process was arrested the superinoculation resulted in a feeble lesion or specific swelling of short duration, or no lesion at all, in spite of the fact that control animals inoculated at the same time with the same material developed a typical initial yaw.

From Table 10, showing the gradual development of immunity as demonstrated by superinfection, it can be seen that yaws monkeys in which the local frambœsic process lasted five months or less took invariably, showing a typical initial yaw upon superinfection. In animals in which the local process remained alive seven months or more the results of superinoculation were invariably negative; that is, a specific swelling developed which disappeared rapidly, or no lesion at all.

month after development of the initial yaw is further brought out by the observation that generalization of the yaws process, either spontaneous or induced by superinfection, has invariably occurred from the third to the fifth month, after initial inoculation, never later. Thus the findings made on superinoculations are supported by the observations made on those animals in which general manifestation of yaws took place.

In connection with the late ulcerative type of lesion the findings are significant. Once the ulcerative lesion has developed and persisted for some time, the following superinfection still results in a lesion, recognizable as a yaw, in which treponemas can be found. We have designated this lesion as feeble, for the reason that its appearance was not that of typical initial yaw, although oozing and crust forming occurred. It always was a short-lived lesion that did not spread so rapidly and extensively as is usual with the initial local yaw, and was characteristic because of the extreme swelling surrounding the lesion. On the other hand, it did not show the character of an ulcerative lesion. This seems to indicate that after the ulcerative lesion had persisted for some time immunity has developed to a higher degree and an ulcerative lesion did not result so completely typical as the one already existing. In other words, the period during which ulcerative forms of yaws spring up is limited, and is shorter than the duration of the existing ulcerative lesions.

The protective immunity in any persistent form of yaws toward new superinfection rises more quickly and to a higher degree than the body's power with regard to the healing of the existing lesions and, to a certain degree, independently of it. It was observed that in the case of an ulcerative lesion the feeble lesion that developed as the result of subsequent superinfection showed far more rapid healing than did the existing ulcerative lesion itself. Metastatic lesions of generalized yaws may persist and harbor viable treponemas months after the animal becomes completely resistant to superinfection. On the other hand, an initial local yaw heals at a time when the animal is still fully susceptible to superinfection.

These findings are significant, in as much as they show that the difference with regard to immunity between the local yaw and generalized early yaws is quantitative. If the local initial yaw persists for a long time, or if repeated development of successive initial yaws is experimentally induced, immunity after a long period of time develops as complete as is possible

in frambœsia. If the initial yaw is followed either by local yaw due to superinfection which develops into an extensive and intensive local lesion or by extensive spontaneous local exacerbation, the natural resistance of the body of the animal to generalization of yaws is lowered. Within a month or so after this allergic phenomenon the first crop of generalized yaws occurs. Without further superinfection this first crop of typical yaws may be followed by a second, a third, and even a fourth crop of specific efflorescences; but in the last crops superficial frambœsides are usually admixed with the eruption of typical yaws, and the ultimate crop, or even the penultimate one, may be composed exclusively of superficial evanescent frambœsides. By this time the immunity had developed to such a degree that upon superinfection neither typical or mild yaw nor late ulcerative lesions developed. In other words, animals that have gone through repeated crops of generalized early yaws manifestations did not develop late ulcerative, so-called "tertiary" lesions, but were at the end of the generalized dissemination immediately as completely immune as is possible in frambœsia. The superinoculation, which was well controlled and checked up by simultaneous inoculation of normal animals, resulted in nonspecific œdematous swelling, possibly with a slight superficial necrosis, or no lesion at all. The resistance to superinoculation set in as soon as the metastatic yaws ceased to crop out, but long before the last remnants of generalized manifestation had healed, and a considerable time before treponemas had disappeared from these lesions.

In order to place the findings recorded in our study of immunity to yaws in a system two kinds of protective immunity in yaws, apart from healing, must be assumed; one is the lytic and the other is the neutralizing immunity. The first type of resistance in monkeys (type A) shows slow development and both immunities (that is, the lytic and the neutralizing) develop and run together as a single line. In other cases (type C) the two kinds of immunity do not run parallel, but the lytic immunity develops to a higher degree than does the neutralizing one. Consequently, deep ulcerative lesions developed, because the majority of the treponemas have been dissolved and their toxic substances liberated, but the body tissues are not able to neutralize these toxic substances and react, either locally with excessive granulation or in remote places by excessive hyper-

keratosis. This theoretical system forces itself on one's mind because of the great similarity of the immunity in yaws to that in vaccine virus.

The healing of a yaws lesion is staged locally within the lesion itself, and in the surrounding tissues in such a manner that the deeper layers of the affected skin heal first and the healing process progresses toward the surface of the skin. In consequence of this the transformation of the typical yaw into the fourth, fifth, and sixth stages of the local yaw is accomplished, and lesions result that may be designated as local or regional framboesides.

If the throwing off into the blood stream of the treponemas from the mother yaw takes place at a time when the resistance of the skin tissues has developed to a certain degree but not to the full intensity, the treponemas localize in the epidermal layer of the skin, as is their nature, but do not multiply as extensively as they do in a fully susceptible skin. Consequent upon the resistance of the skin tissue they are barred from the deeper layers of the cutis and the lesion remains restricted to the superficial parts of the skin. The result is the appearance of metastatic, otherwise generalized framboesides.

The observation made in the course of our experimentation that inflammation and pus formation at the place of inoculation prevent or delay the development of yaws lesions points to the important part which leucocytes play in the destruction of treponemas. An extensive disintegration of the leucocytes was noted by Goodpasture(8) to take place in yaws lesions healing as a consequence of neosalvarsan therapy. It can be easily suspected that this phenomenon helps in the destruction of the treponemas in the lesion.

Everything points to the conclusion that not humoral but cellular immunity is responsible both for the resistance to superinfection and for the healing of the existing lesions, and that the leucocytes play an important part in the healing of the lesions. The healing is independent of the resistance to superinfection or reinfection, or else a local yaw could not heal in the stage of infection when the animal is susceptible to superinfection, even at the very same place in the skin where the yaw has healed. Likewise, the fully developed resistance to superinfection has no immediate effect upon the healing of the existing

early yaws lesion or on the disappearance of the treponemas present therein.

CONCLUSIONS

The second of the three problems set forth in the introduction finds its solution in the following summary.

Immunity to yaws in Philippine monkeys exists. It presents itself in the following ways: First, as resistance to superinoculation; second, as resistance to generalization of the yaws process; third, as a modification of the yaws lesions, both local and generalized.

The resistance to superinoculation is slow in development in a case of persistent local yaw.

The resistance to superinoculation develops much more rapidly as a consequence of generalized manifestations of yaws than it does following local yaws.

The generalization, either spontaneous or due to superinoculation, takes place upon superinfection performed not later than five months after the original inoculation and not sooner than three months.

The resistance to superinoculation is not noticeable until from six to seven months after the original inoculation in case of the local yaw, and immediately upon termination of the cropping out of the generalized yaws in cases of metastatic yaws.

In case of ulcerative lesions the resistance to superinoculation is much delayed.

The resistance to superinoculation lasts at least three years.

As a phenomenon of immunity, in the broad sense of the word, two allergic states exist; namely, one which has the character of a negative phase or a higher susceptibility to superinoculation or susceptibility to excessive local exacerbations. This condition may be followed by general clinical manifestations of yaws; the second allergic state is of the character of an anaphylactic condition in which the body tissues react to superinoculation by excessive granulation and ulceration at the place of inoculation or at the place of the residual local yaw, and by hypertrophic or atrophic skin lesions in places remote from the point of inoculation.

The resistance to superinoculation is developed at the time when yaws manifestations still persist in the form of local

yaw, metastatic yaw, frambœsides, or ulcerative lesions, and when they still contain viable treponemas.

Complete healing of local yaws lesions does not necessarily mean the onset of resistance to superinfection, or vice versa.

Evanescient early and later persistent frambœsides, as well as ulcerative lesions, are signs of partial immunity.

REINFECTION: IMMUNITY AFTER TREATMENT

Having established the fundamental points concerning immunity as it developed in Philippine monkeys in consequence of the various clinical forms of yaws manifestations, we proceeded to the solution of the third problem, as indicated in the introduction; that is, to the question whether the resistance of the yaws-infected monkeys lasts only during the stage of infection or whether it persists after a thorough specific treatment.

(a). *The influence upon immunity to yaws of treatment given in the resistant stage of yaws infection in Philippine monkeys.*—The arrangement of the experiments that fall in this section of investigation was as follows: Animals that developed local yaw, which either persisted spontaneously or was kept alive by successive superinoculations until such time as the animals would no longer take but developed only specific swelling of various degrees or no lesion at all as a consequence of superinoculations, were given intramuscular injections of neosalvarsan. After the treatment with neosalvarsan the animals were reinoculated with yaws.

A similar procedure was adopted in the case of monkeys that had gone through generalized yaws and upon superinoculation proved to be resistant.

(b). *The influence upon immunity of treatment given during the susceptible stage of yaws in Philippine monkeys.*—In another series of experiments the effect of the specific treatment upon reinoculability was tested when given during the early stage of the infection; that is, during the susceptible stage. Treatment was given in these cases at intervals varying from two to seven months after the original successful inoculation. Reinoculation was performed not less than seven months after the initial inoculation; that is, a period of time was allowed to elapse after the initial inoculation, which in animals with

infection uninterrupted by treatment was found sufficiently long to bring about resistance to superinoculation. The treatment was given intramuscularly at the intervals indicated in the protocols. Complete sterilization by "dosis sterilisans magna" was not attempted in these experiments, but the total dosis administered by repeated injections reached or exceeded the amount of 0.01 gram of neosalvarsan per kilogram of body weight. This arrangement of the treatment was adopted owing to the high toxicity of arsenic to our experimental animals. The total amount of the drug given to our experimental animals, therefore, exceeded slightly the amounts known by clinical experience to be sufficient to bring about complete cure of early cases of human yaws.

As the result of the treatment whatever remnants of specific lesions may have been present in these animals from previous inoculation completely disappeared after one or two injections of neosalvarsan. This was true, not only of the specific framboëtic lesions, but also of the nonspecific manifestations, such as alopecia. It was noticed that following the treatment (as a matter of fact, before the entire treatment was accomplished) the hair in places where alopecia had set in began to grow and the animals gradually assumed a normal appearance. They seemed stronger and livelier than before treatment. The serological examinations that gave positive results before treatment were repeated and found negative. It is believed that all the precautions within man's power were taken, and the animals were considered cured. This assumption was furthermore strengthened by the experience accumulated during these investigations that monkeys are less susceptible to generalization of yaws than are humans; and that the framboëtic process left untreated, either local or generalized, lasts in the monkeys a far shorter time than in man and heals spontaneously much more quickly. It was concluded, therefore, that framboësia will be even more amenable to the specific treatment in monkeys than in man; particularly in view of the observations made with regard to healing of late ulcerative lesions and late persistent framboëtic lesions, which lesions healed in a comparatively short time following a single injection of neosalvarsan. It is a well-known fact that late framboëtic lesions in man do not respond to specific treatment with such great rapidity as the early lesions do.

TABLE 13.—*Showing the results of reinoculation of Philippine monkeys after treatment given during the resistant stage of yaws.^a*

[Tr, treatment; —, negative take.]

Monkey No.	Months after original inoculation.																							
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24						
M.....	tr	—																						
E-15 ^b	tr	—																						
G-6 ^b	tr			—																				
F-13.....	tr				—																			
C-2.....		tr				—																		
O-b.....		—	tr	—																				
J-11.....			tr				—																	
F-12.....			tr				—																	
H-17.....			tr				—																	
B-3.....	—		—	tr	—		tr		—				—											
D-9.....	—		—	tr	—	tr		—																
H-16-b.....		—			tr	—																		
B-2.....				—		—	tr		—	tr			—				—							
A-3.....	—								tr			tr												
L-4.....									tr	—		tr		—										
A-2.....		—		—		—			tr	—														
D-8.....					—		—		tr										—					

^a Results of inoculations performed on these animals previous to the seventh month can be found in schematic protocols.^b Generalized yaws.TABLE 14.—*Showing the results of reinoculation of yaws monkeys, treated in the susceptible stage of infection.*

[Tr, treatment; +, positive take; —, negative take.]

Designation of monkey.	Period of treatment and reinoculation, in months.						
	1	2	3	4	5	6	7
J-16.....	tr						+
E-16.....		tr					+
E-17.....		tr					+
T-10.....			tr				—
M-4.....			tr				—
T-4.....				tr			—
B-4.....				tr			—
J-13.....					tr		—
O-c.....					tr		—
A-5.....					tr		—
M-5.....					tr		—
L-6.....					tr		—
L-5.....					tr		—

From Tables 13 and 14 the following conclusions can be drawn:

When treatment was commenced during the first or the second month (after the original inoculation) the animal remained

susceptible to reinoculation and developed local yaw when inoculated seven months after the original inoculation. The rest of the animals that received treatment later than the third month could not be reinoculated in the seventh month after the original inoculation.

Naturally, as already mentioned, the infection was not terminated by the first injection of neosalvarsan and the immunization process evidently continued for some time after the initial therapeutic injection. It took one week or more before the lesions completely disappeared.

Summarizing the events of experimental infection, superinfection, and reinfection in monkeys as far as concerns this study of immunity, we see that the original inoculation is followed by a long incubation, during which time no signs of local reaction or of serologic changes are noticeable. Following the incubation a lesion begins to develop in the form of a papule located in the most superficial layer of the skin (Plate 28, fig. 1) and containing so few treponemas that, as experience taught us, scraping the lesion at this period in a search for treponemas revealed these, but the progress of the lesion was thereby stopped and the infection terminated. In the early stage of development the yaw remains superficial, the treponemas multiply slowly, and the Wassermann reaction is indefinite or slightly positive. Specific treatment given at this stage will leave the animal reinoculable.

From the third to the fifth month the infection gains the upper hand. The yaws process has reached the deeper layers of the skin (Plate 28, fig. 2) and the treponemas have multiplied considerably. The Wassermann reaction becomes stronger the nearer the infection approaches the fifth month. Local exacerbations take place during this period, assume at times an unusual extent and intensity (Plate 3), and contain enormous numbers of treponemas. Generalization of the yaws process takes place between the third and the fifth month. Then gradually, even though rather suddenly, the full resistance to superinfection appears. It is heralded sometimes by a feeble lesion upon superinfection in case of local yaw, and by appearance of frambœsides in case of generalized yaws.

If our supposition that the late penetration of the treponemas into the deep tissues of the skin is responsible for the delay in the development of immunity is true, then it must be possible not only that susceptible animals can be immunized by sub-

cutaneous infection without development of yaws, but also that the immunity conveyed in this manner should develop much more quickly than it does following development of a local yaw and about as rapidly as does that following a generalized yaws eruption. The experiment discussed in the following paragraph proves this contention. (See Table 15.)

TABLE 15.—*Showing results of subcutaneous immunization without yaws skin manifestation.*

[+, positive take; —, negative take; + + +, strong Wassermann reaction; + + + +, very strong Wassermann reaction; 0, not done.]

Monkey No.	Subcutaneous injection of yaws material.			
	First.	Second.	Third.	Fourth.
D-13	II-3-27	1 week.....	2 weeks.....	5 weeks.....
D-12	do.....	do.....	do.....	do.....
N-12	do.....	do.....	do.....	do.....
Normal control	0	0	0	0
Do	0	0	0	0

Monkey No.	Intradermal infection with yaws material.			Wassermann re- action.
	Time after—		Result.	
	First in- jection.	Last in- jection.		
D-13	6 weeks.....	1 week.....	+	0
D-12	16 weeks.....	12 weeks.....	—	+++
N-12	do.....	do.....	—	++++
Normal control	VI-4-27	0	+	0
Do	III-15-27	0	+	0

Three monkeys received, within five weeks, four subcutaneous injections of yaws material containing numerous treponemas. No lesions developed at the place of the subcutaneous injection, but a local swelling did appear. Following this process of immunization one of the three animals was infected intradermally with yaws one week after the last injection and six weeks after the first subcutaneous injection. In due time this monkey developed a typical yaw, showing that the animal was still susceptible at the time of inoculation. The other two animals were infected in a similar way four months after the first sub-

cutaneous injection and three months after the last subcutaneous injection. They failed to develop a local yaw or any other signs of yaws infection, even though the same material when used for intradermal infection of a normal control animal brought about the development of typical yaws.

Direct conclusions can be drawn from this experiment; that is, that immunity develops as a result of subcutaneous inoculation without clinical development of yaws, and that the time of development of immunity is shortened. It develops later than six weeks and earlier than four months after the initial subcutaneous injection of yaws material. It is interesting to note that the animals gave a rather strong Wassermann reaction without ever showing any sign of clinical yaws at all.

Evidence seems to be afforded in this experiment that our contention expressed previously is correct; that is, that during the first two months or so no immunity develops as a consequence of intradermal inoculation and that the immunity begins to develop at the end of the second month and in the third, fourth, and fifth months, when the yaws have reached the deeper layers of the skin. By the arrangement adopted in this experiment we turned aside the period of incubation and the period during which the yaws remain superficial and placed the experimental animals right in the third or fourth month of the yaws process with regard to immunity. Once the fact has been established that immunization to yaws can be carried out by subcutaneous inoculation without production of a yaw, which process may be called a paradermal immunization, there evolve further problems with which, however, we are not concerned at present.

One is naturally tempted to draw far-reaching conclusions, and further interesting investigations are suggested. This finding gives food for thought. The question may be asked: Is it advisable in treponematous infections to terminate the infection in the early stage by abortive treatment, or is it preferable and in the interest of the individual affected to allow the body to reach that stage of infection which still is curable but leaves the individual in a condition of resistance to further infection and to late manifestations?

Is it possible to crowd within the short time of the incubation of general dissemination of yaws a sufficient number of subcutaneous injections without the production of the clinical lesion that would prevent the eruption of general clinical manifestations due to the immunization process itself? In other words,

will it ever be possible to work out a method of immunization against treponematous infections similar to that in use for immunization against rabies, during the incubation period?

These are, of course, suggestions that necessarily occur, and much experimentation will be necessary before any answer can be given. Fortunately, we possess in the monkey an excellent experimental animal, so there should be no great difficulty in working out this problem on animals.

LATENT INFECTION AND FRAMBÆSIC LYMPHADENITIS ¹⁰

By latent infection we mean that stage of treponematous infection when the clinical manifestations and other symptoms have disappeared, either spontaneously or as the result of treatment, but the treponemas have survived within the tissues of the body and again produced later, after a period of latency, clinical manifestations and symptoms. It is in this sense that the term latent infection is to be interpreted in this section of our experimental work.

In order to ascertain whether or not such condition as defined above exists in experimental yaws we proceeded in two directions:

First, we watched for a relapse in those monkeys that had either been cured or been healed spontaneously. This observation was continued for a period of months.

Second, we endeavored to ascertain the survival of treponemas in those organs of experimental animals that, in a disease like frambæsia tropica, would naturally be the storage place of treponemas.

The second investigation was carried on in two ways; namely, (1) we searched for treponemas by means of microscopic dark-field examination; and (2) we endeavored to prove their presence and at the same time their viability by means of inoculation into healthy experimental animals.

As a focus of treponemas where they would most likely be found we took the regional glands corresponding to the active, healing, or healed lesion. It has been known since the time of Castellani's early investigations on yaws that *Treponema pertenue* may be found in the glands corresponding to the frambæsic lesion in experimental animals.

¹⁰ C. M. Hasselmann, formerly of the University-Clinic for Dermatology, Syphilis, and Genito-urinary Diseases, Frankfurt a. M., Germany, and of the Tropical Institute at Hamburg, collaborated in the preparation of this section, pages 297 to 305.

This fundamental fact having been established it remained to be seen what importance it bears upon the maintenance of latent infection and subsequent relapses. It is not to be wondered that a microörganism which penetrates as easily as does *Treponema* will find its way through the lymphatic spaces into the corresponding regional gland. There may be merely a mechanical deposition of the treponemas in the regional gland where they remain for some time and are destroyed then and there, or it may mean that they are deposited there to stay, or they may pass through this gland and work their way through to other parts of the body. It becomes important, therefore, for the interpretation of the positive findings of treponemas in the regional glands, whether they remain in the gland for a sufficient length of time and permanently establish themselves in the lymphatic apparatus or not. Furthermore, the question arises whether or not, if they establish themselves in the lymphatic apparatus, they are capable of invading the body from this hiding place and later causing relapses. Our investigations in this direction are sufficiently extensive to allow of some conclusion.

The result of our observations of the spreading of the early primary yaw leaves no doubt that the treponemas travel from the original place of inoculation through the lymphatic spaces and radiate toward the periphery in a fanlike manner and progress (equal conditions of the skin over which they travel being granted) at about the same rate, thus causing the yaws healing in the center to spread in a more or less regular circle toward the top of the head, when inoculation was performed on the eyebrow.

They spread toward the periphery much faster than they multiply and become fewer as the radius of the circlelike lesion, the center of which is the point of inoculation, becomes longer. In consequence of this the lesion narrows down to a thinner and thinner line, the farther toward the periphery the lesion spreads. This progress in a regular circle of the treponemas is modified when they invade the skin of the root of the nose. Leaving out the eyelids, they spread down the side of the nose in a butterfly effect. In one instance an experimental animal was inoculated on the eyebrow and, due to the admixture of pyogenic bacteria with the inoculum, an erysipelatous infection set in. It extended over the entire eyebrows and down the root of the nose, and finally healed. No yaws lesion developed on

the eyebrows of this animal but, after an unusually long incubation, a typical yaws lesion developed below the right eye. This is the only case among our inoculated animals that developed a yaws lesion at some distance from the original point of inoculation, but the lesion developed in a place that is on the route by which the spreading lesion always progresses from the eyebrow down the side of the nose. It clearly indicates that treponemas travel or are carried through lymphatic spaces and thus naturally reach the first filter, the regional lymph-gland (see lymphogenic metastases).

The observation on healed and cured monkeys with regard to the relapses has shown that not a single one of the healed or cured monkeys developed a relapse of clinical manifestations, although some of the observations were extended over a period of three years. If we examine the results of our observations on other phases of experimental yaws infection, as given elsewhere in this paper, we can see in the local exacerbation of a spreading or healing local yaw the innate tendency of treponematosus infections toward relapses or exacerbations well pronounced. In that respect, therefore, the monkey organism behaves very similar to that of man where likewise periods of lull followed by a period of exacerbation in an existing lesion can be clearly discerned. However, the fact that no relapse was noticed among our numerous experimental animals is not to be attributed to the difference in behavior of the body organism of the monkey from that of man. As long as the lesion exists and before the immunity has developed to a sufficient degree to prevent, the local exacerbations and metastatic lesions may be expected, in monkey as well as in man. The absolute lack of relapses following the disappearance of the clinical lesion must therefore be interpreted in the following way: The immunity that has developed in the meantime prevents the treponemas existing in the lesion from metastatic spreading toward the other parts of the body and, following the healing of all skin lesions, there is in yaws no permanent deposition of treponemas in the lymphatic apparatus or elsewhere from which the relapses might originate. The immunity develops rapidly enough and is so lasting that the period of the metastatic dissemination of *Treponema pertenue*, in monkeys in particular, is limited. Even though they may, at the time of metastatic distribution, reach other organs than the skin they do not, according to their nature, gain a foothold in these organs. The typical metastatic lesions

that have been described in this paper cannot be explained in any other way than as originating through hæmatogenic dissemination.

From our study of the yaws infection in Philippine monkeys the only possibility of latent infection followed by relapses would be as in the following coincidence. We noticed that between the third and the fifth month of infection and due to superinfection a generalization of yaws may take place. This generalization is heralded by very intensive local exacerbation of the existing lesion. It is at this time, when the exacerbation takes place in an eruptive manner, that the hæmatogenic distribution of the treponemas takes place. We have noticed that, following the occurrence of intensive local exacerbation, the generalized skin manifestations, if they occur at all, will be noticed within about four or six weeks from the time of the exacerbation. It must be presumed, from this time relation between the occurrence of the generalized skin manifestation and the occurrence of the local exacerbation, that the actual dissemination of the treponemas happens simultaneously with the local exacerbations. The time between these two phenomena agrees well with the incubation of a local yaw; that is, the period between the time of inoculation and the time when the local lesion assumes a clinical form of beginning yaw. If it so happened that the exacerbated local yaw would heal completely before the incubation period of the metastatic yaws has elapsed, we should have a short period of latent infection in yaws where the animal, or the man for that matter, shows no evident lesions but in due time develops a crop of metastatic yaws.

Although the incubation of the primary yaw in a normal individual man or monkey is fairly constant, yet we have seen in human volunteers that the incubation of a reinoculation may be shortened or lengthened.⁽²⁹⁾ Similar prolongation of the incubation period was noticed in monkeys in sporadic cases; the shortest observed was sixteen days, and the longest was fifty-two days. Therefore, the theoretical possibility of a latent infection in yaws exists, and the organ in which the treponemas remain dormant for longer than twenty-six days is the skin. Therefore, we may claim that in yaws the latency is theoretically possible but very unlikely, on account of the fact that the mother yaw usually remains active up to the time when the generalized distribution occurs, or even longer. The latency,

as we interpret it (that is, latency followed by relapses), is determined by the time relation between the healing of the lesions and the duration of incubation of metastatic yaws. The quicker the healing and the longer the incubation the longer will be the period of latency. Once the lesions are completely healed and the maximum incubation period has expired, without the occurrence of relapses, the further propagation of the yaws process becomes impossible.

Therefore, no evidence was found in our observations that relapses would occur in animals with the local, the local and generalized yaws, or the local and late ulcerative form of yaws (see Table 16).

The microscopic examination of the lymph glands by means of dark-field illumination resulted in negative findings, not only in animals with healed or cured yaws, but also in animals with active yaws. This observation entitles us to only one conclusion; that is, that in any case of experimental yaws treponemas in the regional lymphatic node, if present at all, are present in far smaller numbers and they do not multiply there to such an extent as they do in the corresponding skin lesion.

Table 17 shows the results of our inoculation experiments.

TABLE 16.—*Showing the results of clinical observations of healed yaws in monkeys with respect to relapses.*

Number of monkeys used.	Clinical form of yaws.	Duration of observation.	Relapses occurred in—
		<i>Months.</i>	
Two.....	Local.....	1	0
Two.....	do.....	2	0
One.....	do.....	3	0
One.....	Generalized.....	3	0
Five.....	Local.....	4	0
One.....	do.....	5	0
Two.....	do.....	6	0
One.....	Generalized.....	9	0
Four.....	Local.....	9	0
Five.....	do.....	10	0
One.....	Generalized.....	10	0
Three.....	Local.....	11	0
Two.....	do.....	12	0
One.....	do.....	14	0
One.....	do.....	15	0
One.....	do.....	16	0
One.....	do.....	19	0
One.....	do.....	23	0

TABLE 17.—Showing the results of lymph gland inoculations in Philippine monkeys.

[+, positive; —, negative; tr, treated with neosalvarsan.]

Recipient monkey.	Lesion.			Trepone- mas in lesion.	Result.		Donor monkey.
	Active.	Healing.	Healed.		Micros- copic.	Take.	
R-2.....	+	—	—	+	—	—	T-13
R-2.....	+	—	—	+	—	—	Y-2
K-2.....	+	—	—	+	—	—	H-21
K-7.....	+	—	—	+	—	+	J-15
A-6.....	+	+	—	+	—	+	B-5
P-14.....	+	—	—	+	—	—	A-7
N-15.....	+	+	—	+	—	—	B-5
L-7.....	—	+	—	+	—	+	G-9
Y-5.....	+	+	—	+	—	—	A-6
Y-5.....	+	—	—	+	—	—	O-d
Y-5.....	—	—	+	—	—	—	B-6
Y-4.....	—	—	+	—	—	—	P-13
Y-4.....	—	—	+	—	—	—	A-7
Y-4.....	+	—	—	+	—	—	G-10
Y-6.....	+ late	+	—	—	—	—	H-18
Y-6.....	+ tr	—	—	+	—	—	Baby I
Y-3.....	—	—	+ tr	—	—	—	B-K-3
Y-3.....	—	—	+ tr	—	—	—	B-K-2

The procedure followed in this investigation was to remove the corresponding regional gland (that is, the inguinal gland) surgically and aseptically. The gland was triturated in a sterile mortar and a small amount of salt solution added. The emulsion of practically the entire gland was taken up in a small hypodermic syringe and injected intradermally, following the method indicated in the beginning of this paper. The remnant of the emulsion was used for microscopic dark-field examination.

We encountered no difficulty in locating the healed lesion. Besides our records, we used as a guide the persistent pigmentation of the scrotum that remained for a long time after the healing of the lesion. From Table 17 it is evident that the injection of the emulsified lymph gland produced a yaws lesion in only a few instances. These were glands taken from monkeys with active lesions. However, several inoculations of glands from monkeys with active lesions failed to produce yaws lesions, and not a single inoculation of lymph glands from monkeys with healed or cured yaws produced yaws lesions. From this negative evidence, combined with the results of our microscopic examinations and the results of observations on relapses in cured or healed yaws monkeys, we believe we are justified

in claiming that the invasion of treponemas into the lymphatic apparatus of experimental yaws monkeys has no significance with regard to the interpretation of latent infection. It would not be surprising to find that the treponemas survive in the lymph glands after the corresponding lesion has healed. If this be the case an explanation other than latent infection would be more justified. We find that active yaws lesions last at times for months after the onset of the resistance to reinoculation, and it is the developed immunity that prevents further metastatic spreading of the yaws process to other parts of the body. The treponemas remain at the place of the lesion until the healing process has removed them entirely.

That this interpretation is correct is brought out by the observation on animals and man who developed late ulcerative yaws lesions without going through the generalized metastatic stage. This condition of body shows a long-protracted period of reinoculability and also long-delayed healing of the ulcerative lesion. In spite of the fact that the healing is protracted in the cases of ulcerative lesions, the animals, as is the case in man, do not develop further generalization even though a focus has been established by the development of the chronic lesion in which treponemas, evidently in small numbers, maintained themselves for months. Partial immunity has developed by that time, which is sufficient to prevent the generalization, but not sufficient to prevent development of an atypical yaw as a consequence of superinfection.

In this connection the question necessarily arises whether the resistance to inoculation of yaws, as evident in experiments on animals and humans, is a sign of immunity or a sign of latent infection, as claimed by some. With regard to yaws, whatever the condition in other treponematous diseases may be, at least as far as animals are concerned, no evidence of latent infection has been noticed in our experimental observations extending over more than three years. Unless a spontaneous eruption of yaws is noticed in animals that have been perfectly free from any manifestations or symptoms of yaws due to thorough treatment or spontaneous recovery, it would be fallacy to speak of latent infection, since there is neither indication nor sign of such.

If we consider as a working basis the argument that latent infection is responsible for the resistance to reinoculation we should expect that, in experimental cases of late ulcerative, so-called "tertiary" lesions of long duration, the resistance to reinoc-

ulation would be much greater than in cases that have run a rapid and extensive course characterized by repeated crops of yaws of short duration. In looking over our tabulated results and the results of experiments on late human cases of yaws, (29) we see that quite the opposite is the case. In the first place, not a single one of the generalized cases of yaws in monkeys developed so-called "tertiary" lesions, but they proved most resistant to superinfection and developed this resistance in a very short time. On the other hand, those animals that after a long course of mild local yaw developed so-called "tertiary" lesions were repeatedly reinoculable, and their resistance did not become marked until after long persistence of the tertiary lesions. These findings cannot be brought into harmony with the theory that latent infection is responsible for the resistance to superinoculation. Once the duration of yaws infection, in patients and in animals alike, has extended over the border line of reinoculability, treatment brings about a rapid healing of the lesion but has no effect whatsoever on their resistance to reinoculation.

Evidence is on hand that Philippine monkeys are more resistant to yaws than are humans. At least, with regard to the generalization, the statement is unquestionably true. It is furthermore an established fact that resistance to superinfection is more nearly complete and develops much earlier in the generalized stage of yaws in monkeys than it does in man. It is hardly conceivable that "latent infection" should develop more quickly and to a higher degree in a resistant monkey than in a susceptible man.

The failure to realize the independence of healing of treponematous lesions from the development of resistance to superinfection or reinfection led to the theory that latent infection is the cause of the resistance. It is confusing the cause with the effect. A similar condition, where immunity brings about a localization of infection without in any way injuring the microorganism, is not unknown in bacterial immunity. One instance is the immunity following active immunization with aggresins against symptomatic anthrax. (27)

It is obvious from this that reinoculation cannot be used as a criterion for complete cure or sterilization of the body organism of either man or animal.

First of all the man, like the animal, can be superinfected while the infection exists in a form of local yaws (for six months), in a form of generalized yaws as long as the metas-

tatic dissemination continues, and in a late ulcerative form practically during the entire duration of the active ulcerative lesion.

On the other hand, superinfection is not successful after the seventh month, while evident lesions persist for months and treponemas persist in the lesions for a long time after the body organism became completely resistant to either artificial superinfection or to spontaneous generalization.

The occasional presence in small numbers of *Treponema pertenue* within the regional glands indicates the way by which the treponemas travel and in certain cases, particularly as a consequence of superinfection, produce generalization. In a great majority of experimental cases, however, they are halted by the first barrier, the corresponding lymph gland, and perish then and there. Thus they are prevented from reaching their goal, the skin, the only organ where they produce characteristic lesions and can persist for a long time, particularly in the late so-called "tertiary" stage.

The periodic broadcasting of the treponemas into the blood stream, followed by cropping out of metastatic lesions on the skin, is brought to a standstill by the immunity which localizes the infection in the lesions that have already developed and prevents further metastatic spreading. Consequently, the period of the appearance of the metastatic yaws lesion is limited and its duration dependent upon the onset of immunity. Likewise, the partial immunity that develops in the animals with late so-called "tertiary" lesions is responsible for the finding that, once an ulcerative lesion has developed on the skin, although the normal skin of the same animal is still susceptible to development of an atypical yaws lesion, no generalization takes place. The character of immunity may, therefore, be defined as an ability on the part of the body to localize the infection and, although the existing lesion may spread by continuity, no new metastatic lesions develop. In this respect the immunity resembles very much the antiaggressive immunity as known in certain bacterial infection and, again, the importance of the lymphatic apparatus in the destruction of the treponemas is brought into view.

SIGNIFICANCE OF EXPERIMENTAL FINDINGS PRESENTED

Aside from the weight of proof of the experimental evidence brought forth in this investigation with regard to the etiology

and the pathogenesis of conditions such as gangosa, keratoderma plantare, psoriasis palmaris, and other early evanescent frambœsides, these experimental findings have a great significance with regard to the interpretation of immunity in yaws. The subject of relapses in yaws has been loosely discussed from a clinical standpoint. As a rule, a case of yaws that again develops frambœsia after treatment is considered a relapse. The clinical cases of yaws are ambulatory patients and not cases under strict control. The possibility of reinfection is generally not seriously considered by the clinicians and epidemiologists. To those acquainted with syphilis only, the phenomenon of relapses in yaws appears to be a natural thing. In the light of present knowledge, gained by recent experiments on animals and humans, the question of relapses and reinfection in yaws patients must be considered more carefully than has been done hitherto.

With the experimental evidence presented in our researches, we can explain and understand certain disagreements in experimental infection and reinfection performed on humans. The irregular results of reinoculation of yaws patients, as published in the literature, could not heretofore be placed in any comprehensible system.

Omitting the discussion of experiments of this kind on humans performed elsewhere, because of lack of acquaintance with the details, I shall discuss only those of my own experience that have been performed during the last sixteen years in the Philippines.

Very illustrative experiments were those of Sellards and Goodpasture⁽²⁹⁾ and of Sellards, Lacy, and Schöbl.⁽³⁰⁾ Briefly stated, the experiments were as follows:

In 1922 and six months after treatment with neosalvarsan four patients were inoculated with yaws. Two of the four cases developed lesions of sufficient extent to require treatment with neosalvarsan. After an interval of more than two years the susceptibility of these four patients to yaws was tested again by reinoculation. They had received no further treatment in the meantime.

The result of this and subsequent reinoculations was as follows:

Upon first reinoculation patients 1 and 4 showed lesions recognizable as yaws. While No. 1 developed early generalized lesions after five weeks, No. 4 failed to develop them after four months. Nos. 2 and 3 exhibited no lesion at the place

of inoculation recognizable as yaws. Another treatment with neosalvarsan was given and the same four patients were reinoculated with the following result: No. 1 again developed a typical granuloma and generalized lesions, while No. 4, like Nos. 2 and 3, remained negative as far as yaws lesions were concerned.

These results are rather confusing and, at the time the researches were finished, were not quite comprehensible; but, with the accumulated experimental evidence with regard to immunity to yaws in animals, the reason can be seen at once for the different behavior of the four patients, all of whom in the beginning and at the time of the first treatment presented fully developed, generalized, so-called "secondary" yaws. The explanation lies in Table 1 of Lacy and Sellards.⁽¹²⁾ It is evident that at the time the first treatment was given the infection with yaws had lasted in patient 1 only three months and in patient 4 only eight months, while in patients 2 and 3 it had lasted twelve and twenty-four months, respectively. This shows clearly that if the infection in man, as in animals, has lasted less than seven months the patient or the animal is reinoculable. If, however, the infection has lasted longer than eight months the patient or the animal is no longer reinoculable. While patient 1 was found repeatedly reinoculable when treatment was given after the first, and the second infection lasted less than seven months and therefore he was not immune, patient 4 was at the time of the first treatment just on the border line of reinoculability and therefore gave a positive take (local only) upon the first reinoculation and a negative take on the second reinoculation. Patients 2 and 3 had their natural infection for a sufficiently long time previous to the first treatment to develop their immunity and therefore were not reinoculable, in spite of treatment. This interpretation of the experimental evidence makes the clinical assumption, which lacks all experimental evidence, of relapses questionable. By relapses in this discussion, it is to be strictly understood, are meant the occurrence of yaws in one and the same patient after all of the clinical lesions and symptoms have completely disappeared due to healing or treatment, and does not refer to exacerbation of the existing or vanishing yaws process.

Summarizing briefly, we should state that a patient, like the experimental animal, that went through a typical course of generalized yaws and after the infection had lasted for more than eight months, either healed spontaneously or was treated to such

an extent that all of the specific and nonspecific manifestations of yaws had disappeared, can neither be reinoculated nor contract yaws again.

With regard to the question how long this desirable condition on the part of the patient lasts, we are still in the dark, but it can be reasonably assumed that, in case the patient has gone through typical and repeated crops of generalized yaws within the period of time indicated above, his resistance will last for a long time, if not for life. The fact that the majority of the yaws cases in a given infested locality are children and youths, while the adults are free from yaws manifestations, finds its explanation in our experimental investigation. The experiments of Sellards, Lacy, and Schöbl⁽³⁰⁾ on humans show that the resistance lasts more than two years.

Objections will naturally be raised, and the question will be asked, How can this interpretation explain the existence of late yaws manifestations in old people? Unfortunately, in analogy to syphilis, these lesions are generally considered by exclusive clinicians as relapses of latent yaws. Whether or not this interpretation is correct with regard to syphilis, experimental evidence being lacking, is an open question; but it certainly is not true in cases of yaws. We must bear in mind that framboesia tropica is primarily and in the majority of cases exclusively a skin affection, and that spontaneous healing and therapeutic cure are far more rapid and complete in yaws than in syphilis. Furthermore, a permanent localization of *Treponema pertenue* in the internal organs has not been demonstrated satisfactorily. It certainly is not the rule. It is an open question whether or not the bone lesions in yaws, either early or late, are always due to actual localization of *Treponema pertenue* in the bones or whether it is a process analogous to that of keratoderma plantare.

Furthermore, it must be remembered that ulcerative so-called "tertiary" lesions do not occur metastatically as such, but develop from existing early lesions or (in experimental animals, at least) it has been demonstrated that they occur as a result of superinfection which took place during the second allergic stage. The explanation therefore for the occurrence of late ulcerative lesions of long duration, based on experimental evidence, would be a low-grade infection caused by low-grade reactivity of the body organism toward the infection, which reactivity manifests itself by the negative phase and the con-

sequent occurrence of a sufficient number of metastatic early lesions. Indeed, in late ulcerative cases giving no history whatsoever of early metastatic lesions, so-called "secondaries" are probably the rule rather than the exception. Restricting again our quotation of literature to the work done in the Philippines we find the description of four cases of late ulcerative yaws lesions reported by Ferdinand Schmitter.⁽²⁶⁾ The author says: "The history in each of the above four cases was of an extra-genital papule without secondaries."

Sufficient evidence has been produced that the cases of late yaws in experimental animals are reinoculable, a finding which completely agrees with the experience of Sellards and Goodpasture⁽²⁹⁾ who, experimenting on cases of "clavos," arrived at the same conclusion with regard to humans. The patients, like the experimental animals, who develop late ulcerative so-called "tertiary" lesions, have not gone through crops of generalized yaws manifestations at all, or not a sufficient number of them to develop such a degree of immunity as is conferred on patients who went through a typical initial yaw and had repeated crops of generalized manifestations.

The place of predilection of ulcerative yaws lesions in many patients remarkably coincides with the predilection place of the mother yaw, and the initial yaw not infrequently turns into an ulcerative chronic lesion—so frequently, in fact, that the initial lesion of yaws is given in textbooks erroneously as an ulcer.

The resistance as it develops during the course of generalized yaws in monkeys, and for that matter in man, has all the characteristics of immunity. In the beginning, when the local yaw only develops, the animals are as susceptible to superinfection as are normal animals. Then follows a state of higher susceptibility, a negative phase, manifesting itself by an intensive local process, enormous numbers of treponemas in the lesion, and generalization of the process. This stage is followed by increased resistance to superinfection that becomes complete in due time, is lasting, and is independent of treatment.

CONCLUSIONS

1. The Philippine monkey is an excellent experimental animal, due to its high susceptibility to yaws and on account of the variety of clinical lesions that can be produced experimentally in this animal.

2. The local lesion produced by intradermal inoculation of Philippine monkeys is a yaw clinically and anatomically identical with that produced in human volunteers experimentally.

3. The early metastatic yaws lesions produced in Philippine monkeys by superinfection—that is, the typical metastatic yaw, the ringworm yaw, the early frambœsides including psoriasis palmaris—are clinically and anatomically identical with metastatic manifestations of yaws in humans.

4. The late yaws lesions, such as the ulcerative form, lupus-like lesions, gangosa, and the late frambœsides, such as ichthyotic yaws lesions and the keratoderma plantare as produced in monkeys by superinfection, are clinically and anatomically identical with these lesions as they occur in man.

5. The duration of incubation of local yaw is the same in Philippine monkeys as it has been established to be in human volunteers.

6. The incubation of the metastatic generalization of yaws produced in Philippine monkeys by superinoculation is the same as that found in human volunteers upon experimental inoculation.

7. The duration of early yaws manifestations, as well as that of the late ones, is much shorter in Philippine monkeys than is found by clinical experience to be the case in man.

8. However, the proportion of the duration of early yaws manifestations to the duration of late yaws manifestations is about the same in monkeys as in man.

9. The immunity, which consists of resistance to superinfection and resistance to metastatic generalization as well as of modification of the early and late lesions that take place at the time when the resistance to superinfection starts to develop, set in with Philippine monkeys much earlier than was found to be the case in experimentally inoculated human volunteers.

10. The fact that the period of metastatic dissemination of yaws is much more limited in monkeys than in man is due to the early onset of immunity.

11. The healing of existing yaws lesions, particularly the early ones, is independent of the resistance to superinfection. Yaws lesions in monkeys, as in man, may heal while the animal or the man is still susceptible to superinfection, and existing lesions will persist a long time after the stage of resistance to superinoculation has fully developed.

12. From this it is evident that the reinoculability of yaws animals cannot be used as a criterion for complete therapeutic sterilization of the yaws-infected body organism.

13. The resistance to superinfection once achieved is persistent, and no amount of treatment can cause the animal, once it has become resistant, to take infection again.

14. The Wassermann reaction is indefinite and ephemeral in the case of local yaws. Its strength and persistence depend upon the duration of infection, the number of yaws lesions, the intensity of the lesion and, to a lesser extent, on the number of superinoculations.

15. The Wassermann reaction, if it has become negative due to treatment or spontaneous healing and if all the lesions have disappeared, will reappear upon unsuccessful superinfection or reinoculation with viable material.

16. The serologic reactivity of the body organism to superinfection (that is, the reappearance of the Wassermann reaction and the reactivity of the organism to treatment, which manifests itself as a disappearance of the Wassermann reaction) becomes sluggish upon repeated reinoculations and treatment.

17. The reappearance of a positive Wassermann reaction can be produced in healed and cured animals without recurrence of yaws lesions and, therefore, a positive Wassermann reaction does not necessarily mean the existence of *Treponema pertenue* in the body organism of the animal.

18. The focus from which the treponemas are disseminated into the surrounding tissues, or metastatically into remote parts of the body, is the skin.

19. In lymph glands corresponding to the active lesions *Treponema pertenue* can be found in a fairly high percentage of cases while the early lesion is active, but *Treponema pertenue* was never found in the lymph gland when the lesion had healed, either spontaneously or due to treatment.

20. Spontaneous relapses do not occur in experimental monkeys when they reach the stage of resistance. The temporary stay of *Treponema pertenue* in the regional lymph gland indicates the route through which generalization in yaws takes place, but it has no significance with regard to possible relapses after a period of latency.

21. The latency in yaws followed by relapse depends upon the time relation between the healing of the existing yaws lesions and the incubation period of the metastatic yaws.

ACKNOWLEDGMENTS

The experiments discussed in this paper were undertaken as a continuation of certain investigations into yaws as it occurs in man, and of observations on other problems connected with the disease that were initiated by Dr. A. W. Sellards, of Harvard Medical School, and Dr. G. R. Lacy, of the International Health Board. Through the courtesy of these gentlemen, I was privileged to join them in their observations of the lesions in man that developed as a consequence of inoculation and superinfection, and to carry on the serologic investigations connected with the work. Upon his return to the United States, Doctor Sellards placed at my disposal the animals (monkeys) that he had inoculated with yaws material from patients, and these animals formed the starting point of the work that is set forth in this series of studies. Through the courtesy of Dr. A. W. Sellards, a liberal supply of neosalvarsan was placed at our disposal by H. A. Metz Laboratories, Inc., New York.

Thanks are due to Dr. W. H. Brown, director of the Bureau of Science, for the allowance of funds with which to secure a large number of experimental animals, without which it would have been impossible to carry out this work.

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SCHEMATIC PROTOCOLS OF SUPERINFECTED AND REINFECTED MONKEYS, ARRANGED ALPHABETICALLY IN GROUPS

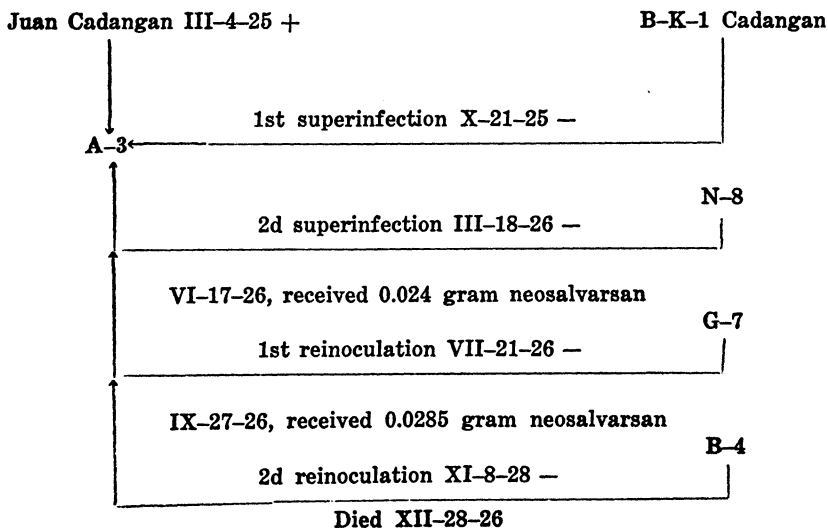
- I. Monkeys with local yaws.
 II. Monkeys with generalized yaws.
 III. Monkeys with late ulcerative yaws and other late forms.
 IV. Monkeys reinoculated after treatment.

The protocols of monkeys that were used for superinfection first and then, seven or more months later, for reinoculation, are listed in groups I, II, and III.

Donor → Recipient

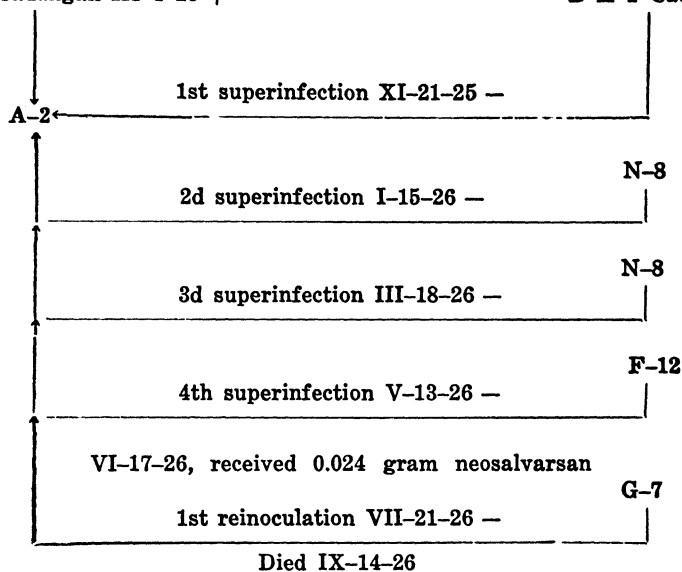
For the sake of easier calculation the months are indicated by Roman numerals, the days and years by Arabic figures. +, positive take; ±, feeble take; —, negative take.

GROUP I. SUPERINFECTION AND REINOCULATION OF POSITIVE YAWS MONKEYS



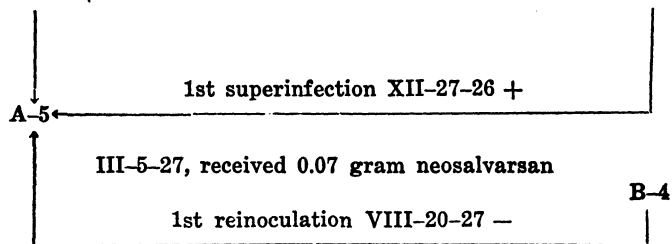
Juan Cadangan III-4-25 +

B-K-1 Cadangan



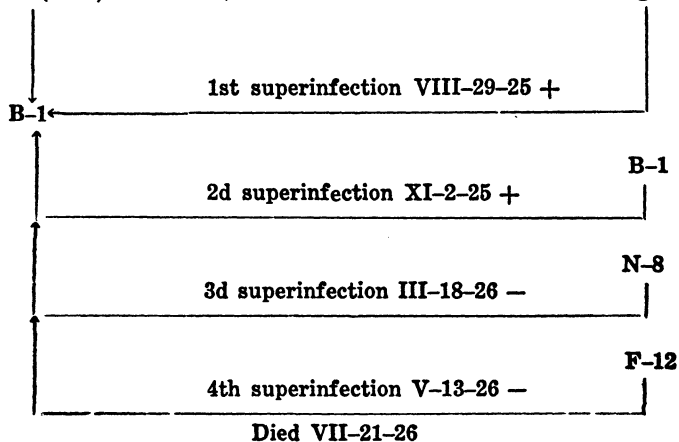
C-3 X-22-26 +

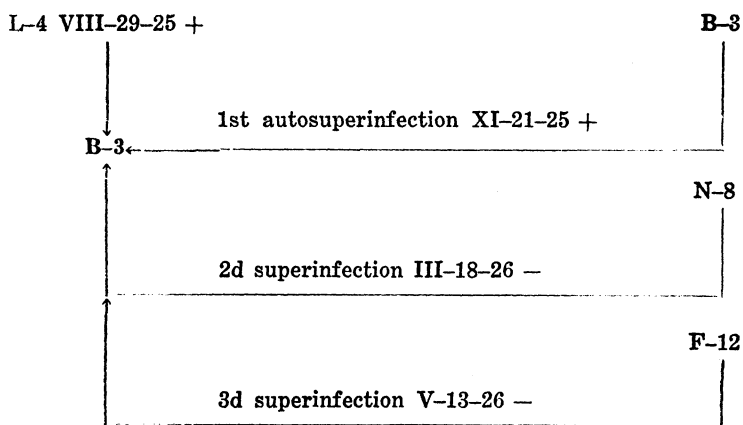
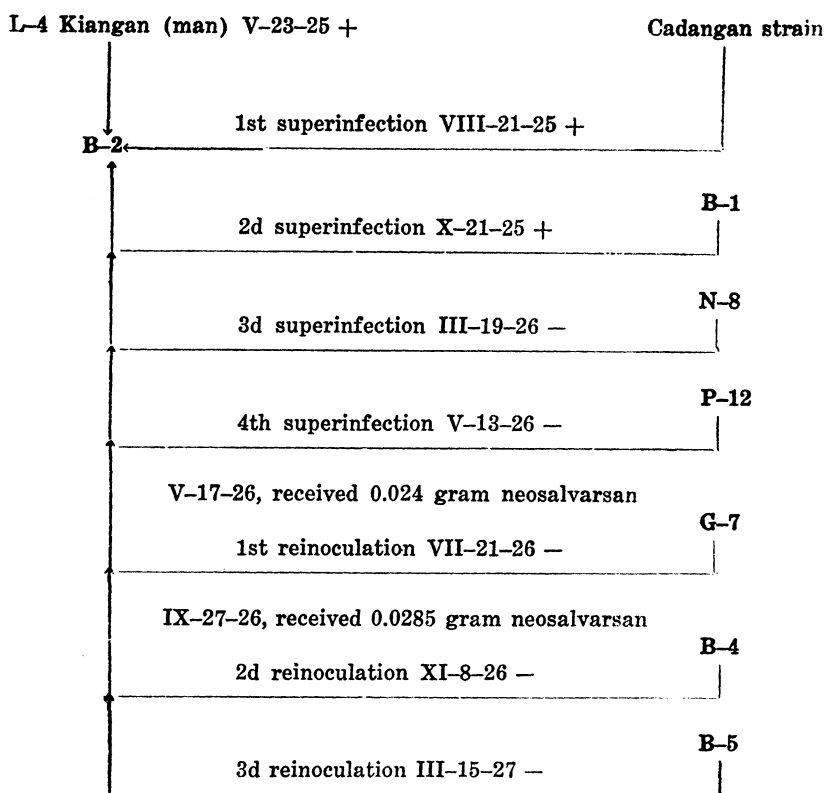
J-16



Kiangnan (man) V-23-25 +

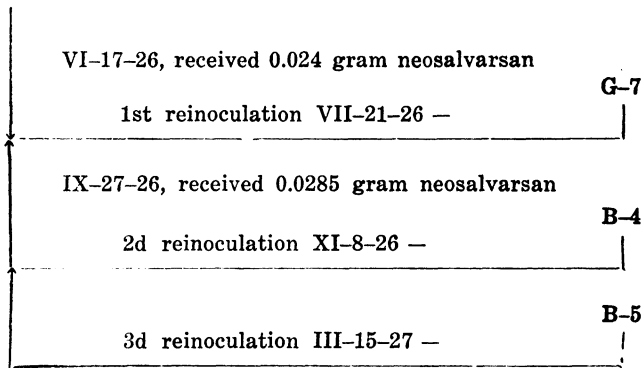
L-4 Cadangan strain





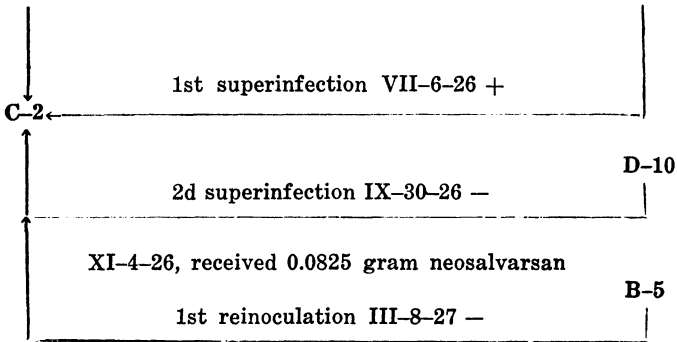
L-4 VIII-29-25 + —Continued

B-3—Continued



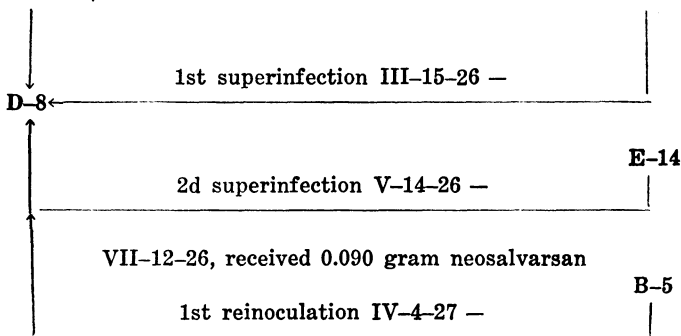
N-8 III-18-26 +

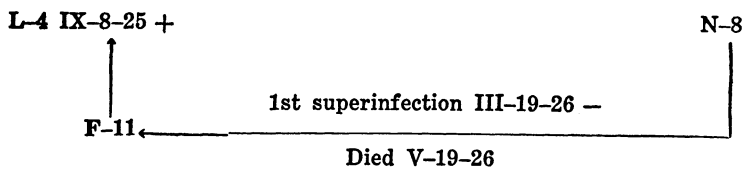
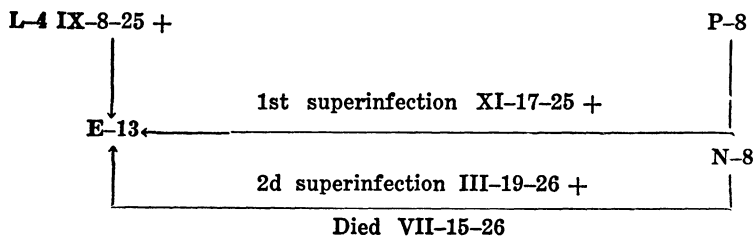
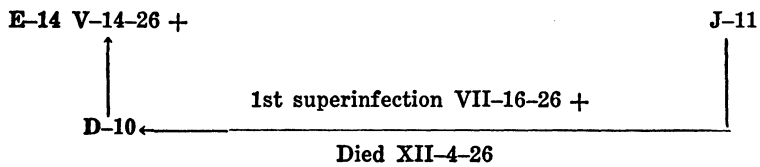
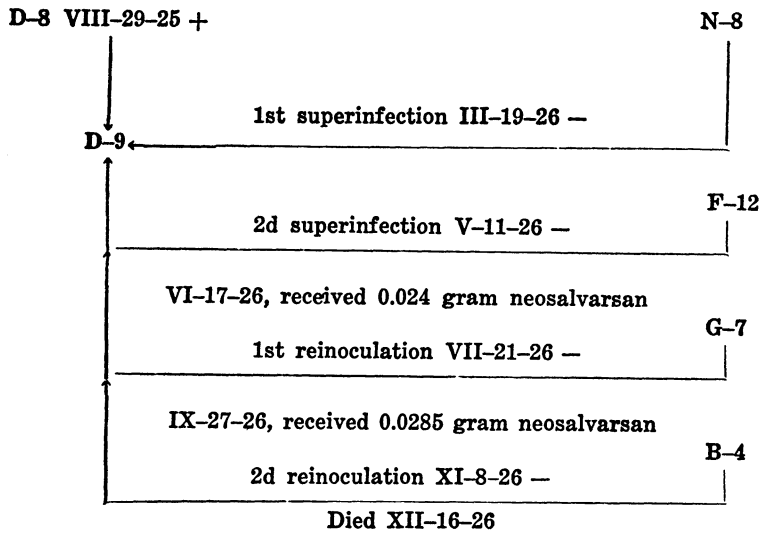
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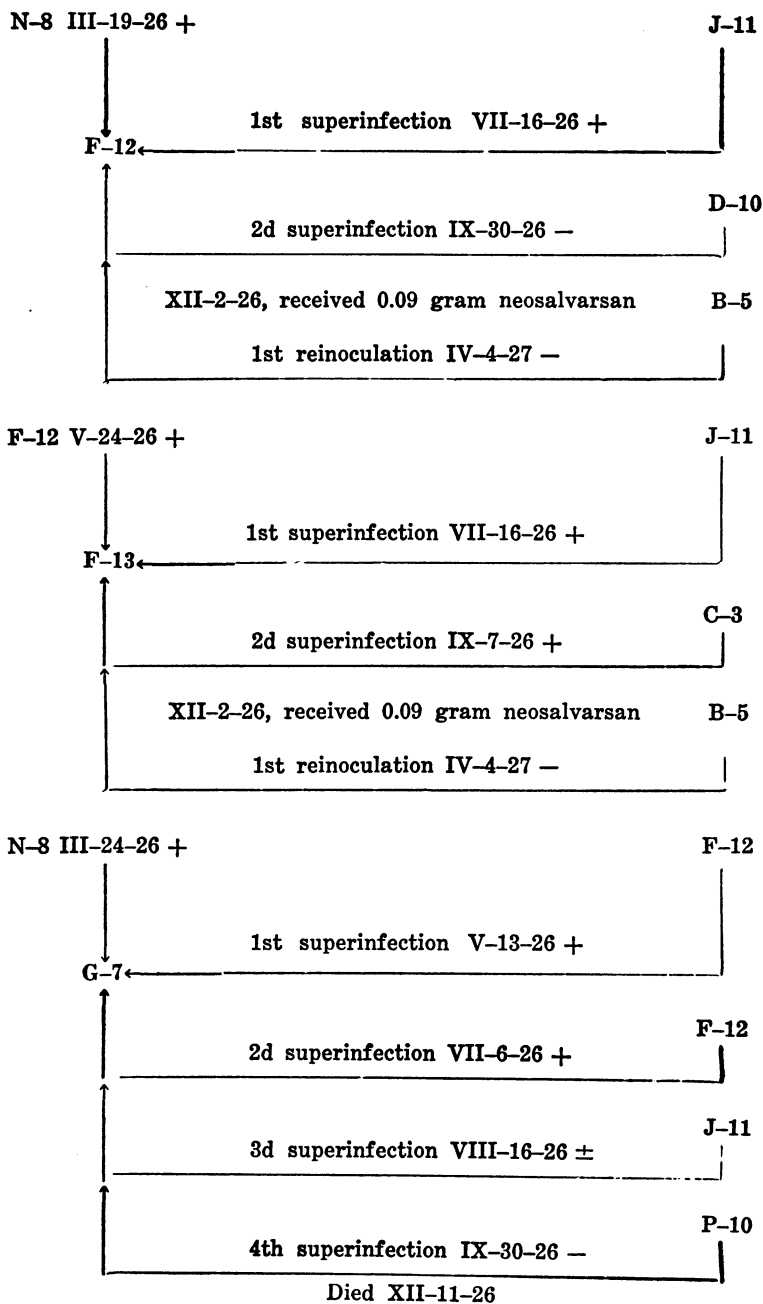


L-4 IV-25-25 +

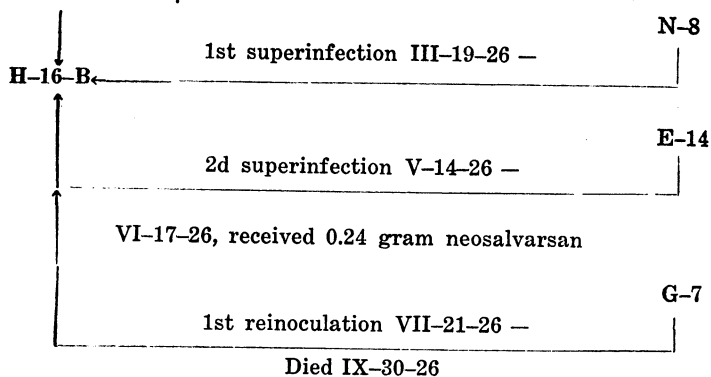
T-1



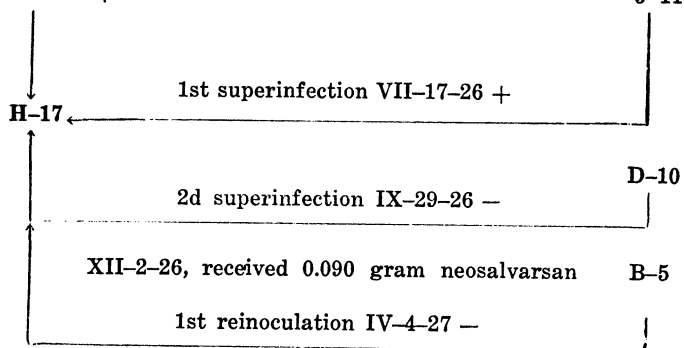




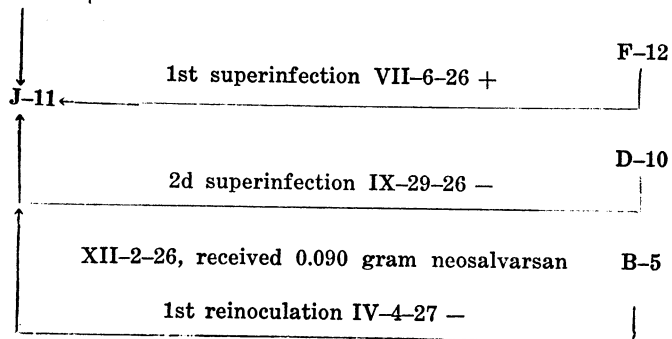
H-16-B VII-30-25 +

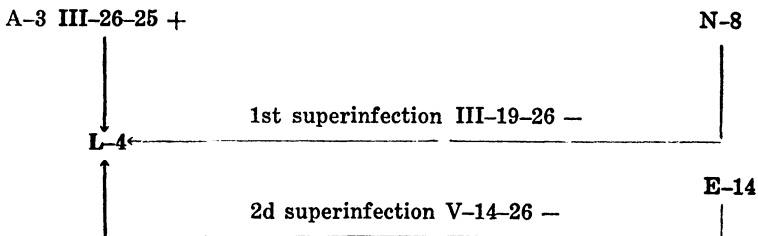
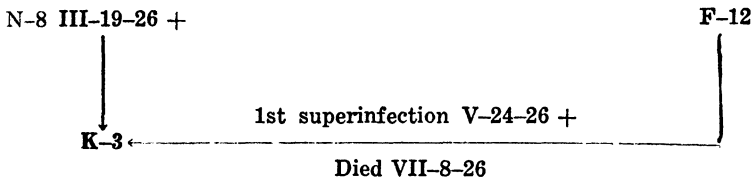
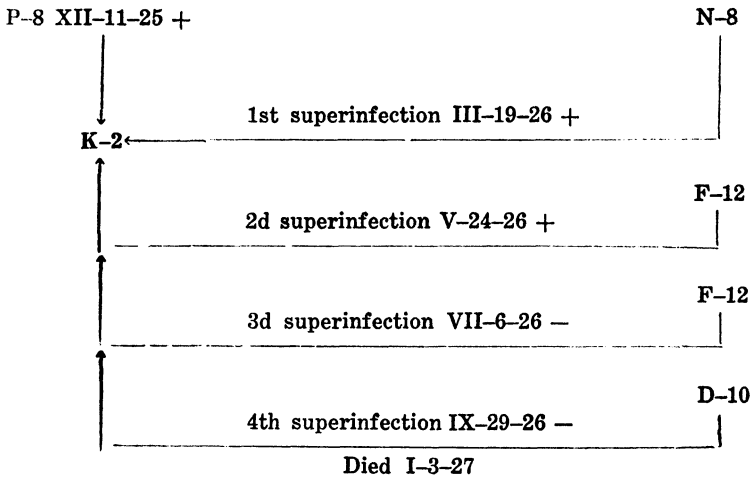
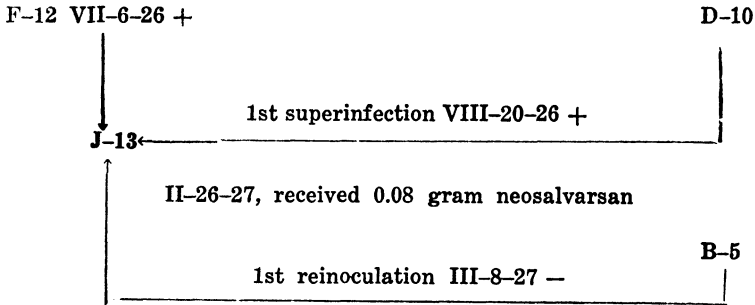


T-1 III-19-26 +



T-1 III-19-26 +





A-3 III-26-25 +—Continued

L-4—Continued

VI-17-26, received 0.024 gram neosalvarsan

1st reinoculation VII-21-26 —

G-7

IX-27-26, received 0.0285 gram neosalvarsan

2d reinoculation XI-8-26 —

B-4

Died I-3-27

J-11 VII-16-26 +

D-10

1st superinfection IX-29-26 +

L-5

XII-2-26, received 0.090 gram neosalvarsan

1st reinoculation III-8-27 —

B-5

B-4 XI-15-26 +

J-16

1st superinoculation XII-27-26 +

L-6

III-5-27, received 0.07 gram neosalvarsan

1st reinoculation VII-20-27 —

B-4

N-8 III-19-26 +

F-12

1st superinfection VII-6-26 +

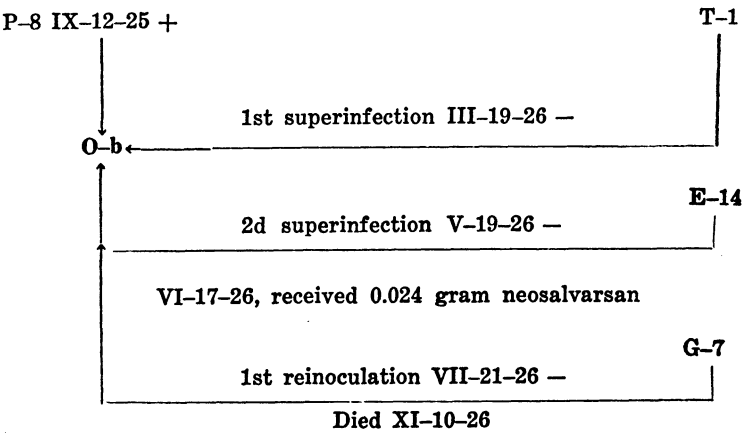
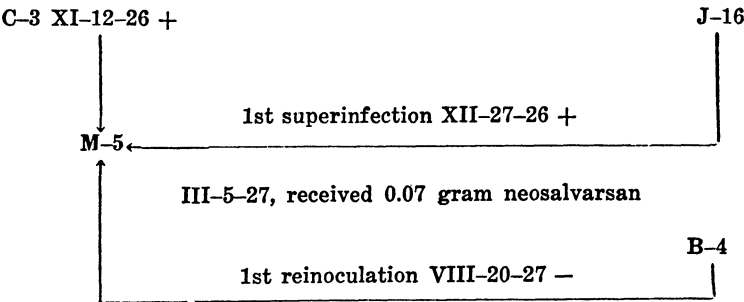
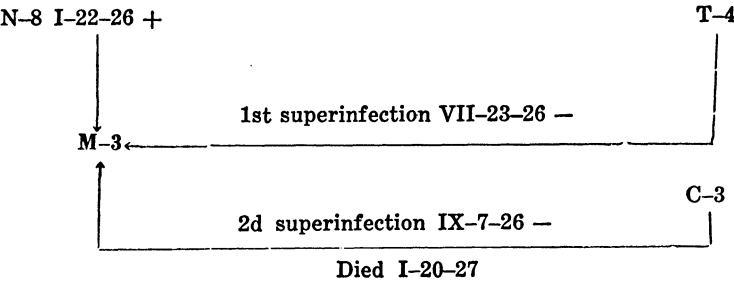
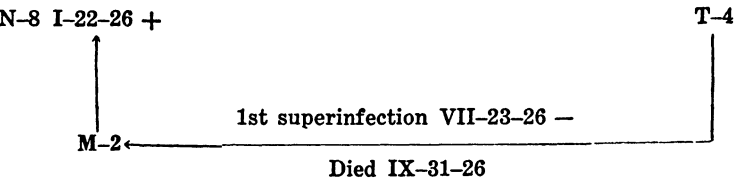
M

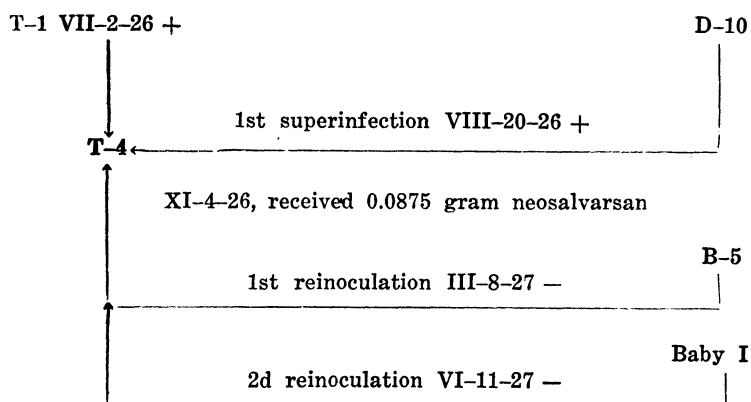
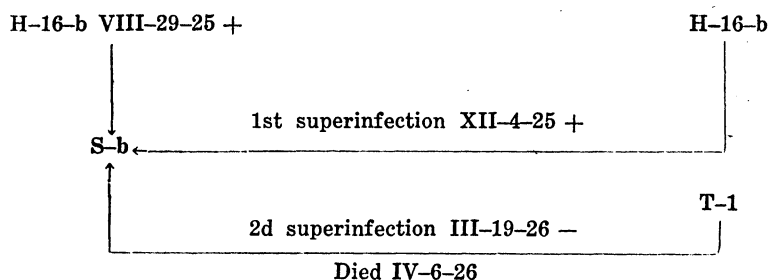
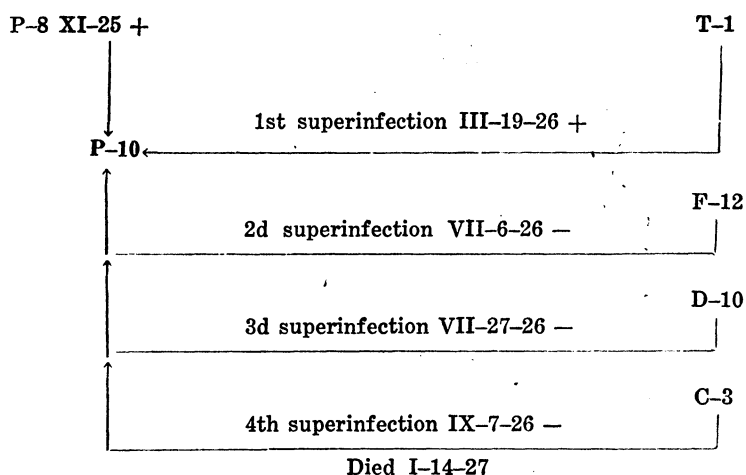
X-1-26, received 0.0240 gram neosalvarsan

1st reinoculation XI-18-26 —

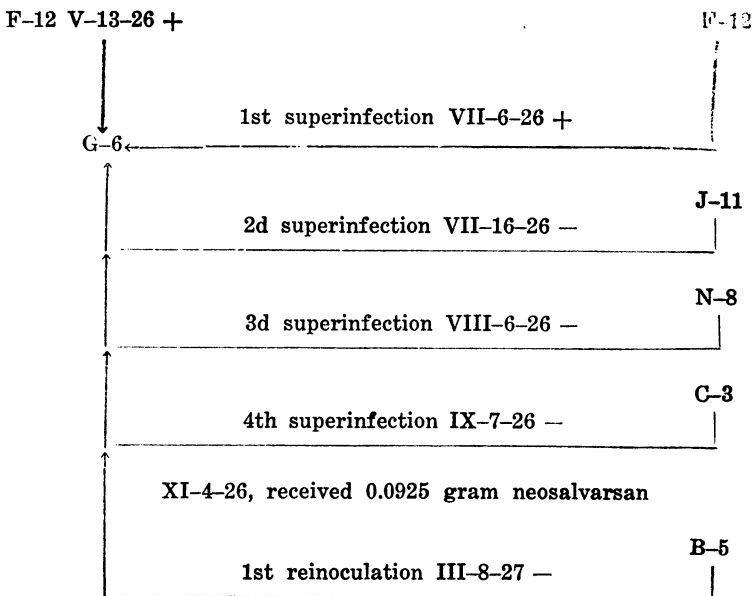
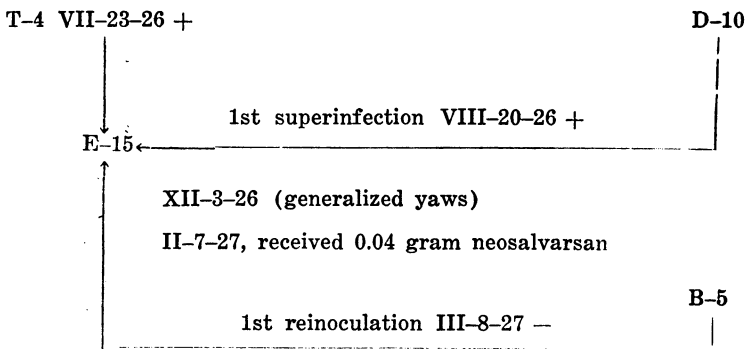
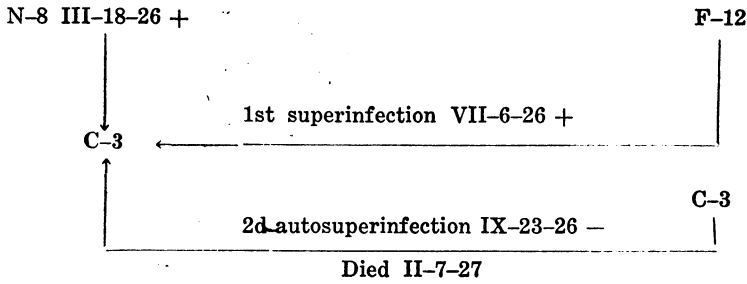
D-10

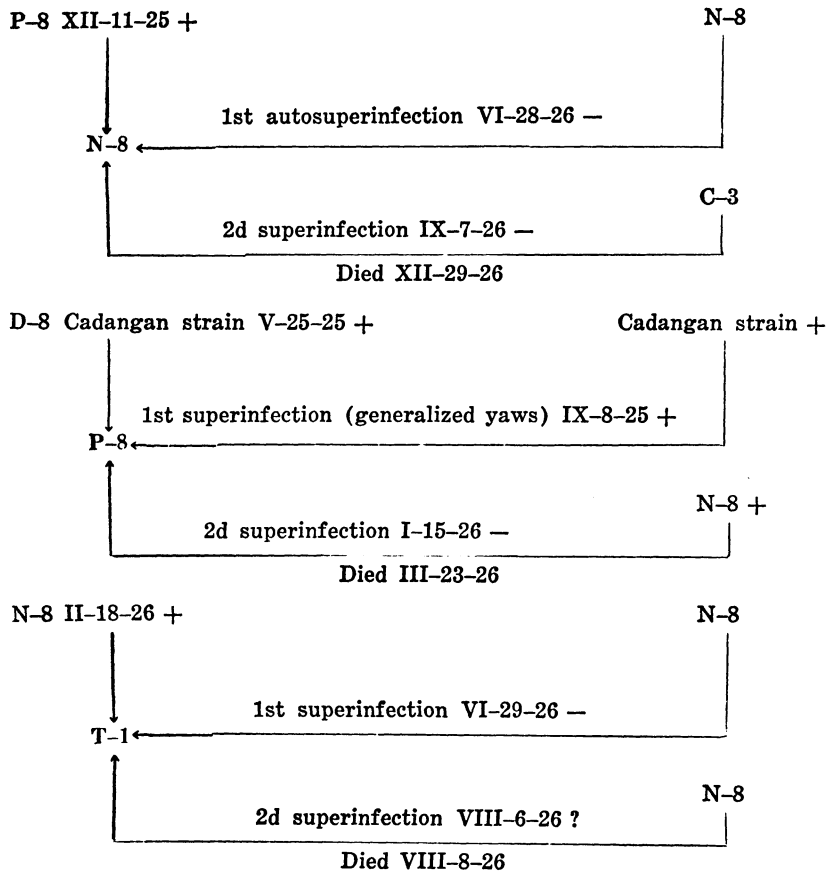
Died XII-27-26





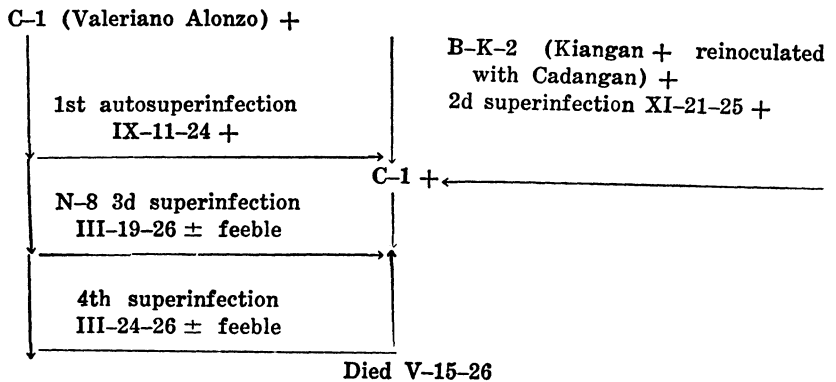
GROUP II. SUPERINFECTION OF POSITIVE YAWS MONKEYS (GENERALIZED YAWS)

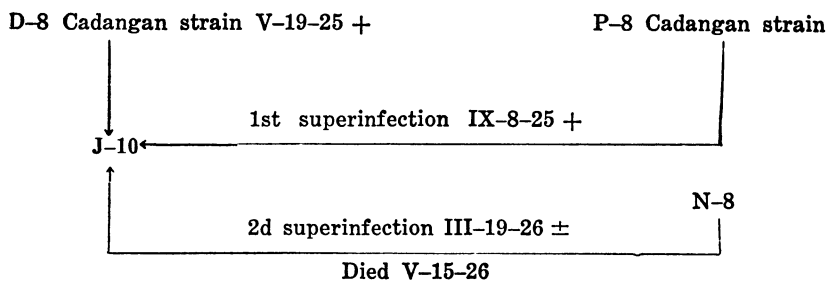
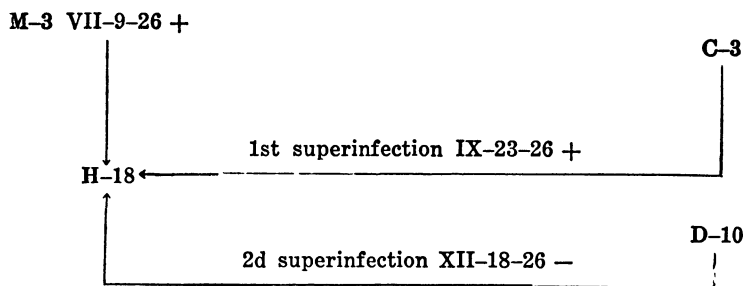




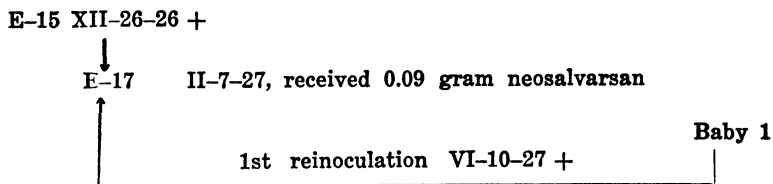
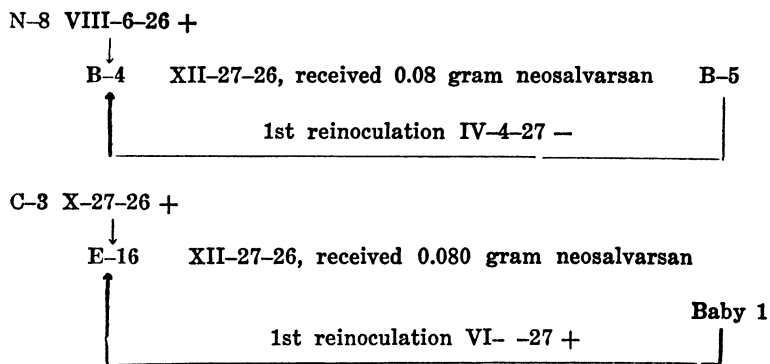
GROUP III. SUPERINFECTION OF POSITIVE YAWS MONKEYS (LATE ULCERATIVE FORM)

Valeriano Alonzo VIII-12-23 +

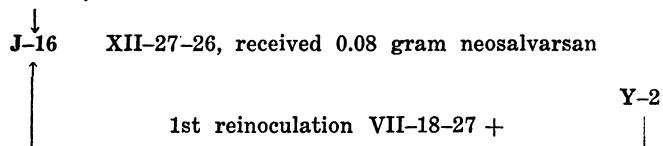




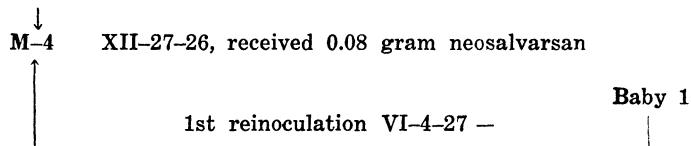
GROUP IV. REINOCULATION OF POSITIVE YAWS MONKEYS



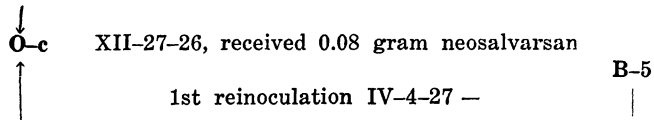
B-4 XI-5-26 +



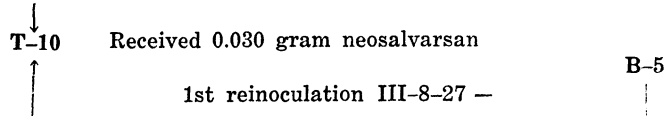
C-3 IX-13-26 +



D-10 VII-27-26 +



D-10 VIII-20-26 +



ILLUSTRATIONS

PLATE 1

- FIG. 1. The initial lesion of yaws on the eyebrows. Three acuminate papules on the inner canthus and a flat extensive papule on the outer canthus of the eyebrow.
2. A well-developed experimental yaw on the left eyebrow spreading down the bridge of the nose and over the forehead.

PLATE 2

- FIG. 1. Initial lesion of experimental yaw on the scrotum. A single papule on the left side of the scrotum and one showing extensive oedema on the prepuce.
2. A well-developed experimental yaw on the skin of the scrotum of a hermaphrodite.

PLATE 3

Extensive local exacerbation on the eyebrows and nose and on the scrotum of a monkey. The original lesion can be seen as a thin line of scabs on the face and on the scrotum. The extensive exacerbation took place within the area already affected by yaws.

PLATE 4

The same monkey as shown in Plate 3, after healing took place and intersected the extensive lesion in such a way that it makes a wrong impression of multiple lesions.

PLATE 5

- FIG. 1. Extensive simultaneous lesion over the eyebrows and the nose as a consequence of superinfection, and a forerunner to a general eruption of yaws.
2. Lymphogenic metastases on the left jaw as a consequence of local exacerbation on the eyebrows.

PLATE 6

- FIG. 1. Rather dry metastatic yaw over the right elbow.
2. Typical metastatic yaw located above the left ankle.

PLATE 7

Metastatic ringworm yaw on the calf of the left leg of the monkey, showing silvery scale-topped papules arranged in a semicircle. A single papule is visible, about 1 centimeter above the outer ankle.

PLATE 8

Metastatic frambeside in the plica cubiti.

PLATE 9

- FIG. 1. Metastatic typical yaws symmetric on the dorsum of the hind feet of a monkey.
2. Metastatic typical yaw on the tail of a monkey.

PLATE 10

Juxta articular location of metastatic lesions on the elbow and wrist; on the left palm, psoriasis palmaris.

PLATE 11

- FIG. 1. Juxta articular and symmetric distribution of a typical yaw on the left olecranon and a semicircularly arranged frambœside round the right elbow.
2. Initial local yaw on the nose.

PLATE 12

Experimental psoriasis palmaris frambœsica in a monkey that developed generalized yaws.

PLATE 13

Maplike arranged desquamative frambœside on the abdomen and the inner portion of the thighs, which becomes confluent in some places and simulates seborrhœa.

PLATE 14

Ichthyotic desquamative dermatosis of the tail and branny desquamative frambœside on the inner surface of the right thigh. Below the point where the tail crosses the left leg a pigmented spot is visible, which is all that is left of the metastatic lesion shown in Plate 6, fig. 2.

PLATE 15

The manner in which the primary yaws lesion enters the nostrils and eventually leads to a nasal form of gangosa.

PLATE 16

- FIG. 1. A metastatic yaw over the left trochanter, showing the manner of circular spreading while the original yaw becomes stationary.
2. The remnant of a lesion due to superinoculation on the right eyebrow. One of the metastatic lesions that developed as a consequence thereof is located in the nasolabial sulcus.

PLATE 17

- FIG. 1. A deep ulcerative lesion on the left ala nasi at the point of superinoculation. Leucoderma and hyperpigmentation over the eyebrows.
2. Spreading primary lesion over the nose from the eyebrows.

PLATE 18

- FIG. 1. A beginning ulcerative lesion of the skin at the root of the nose, September 22, 1926.
2. Leaving a deep scar on healing, lesion has involved the soft parts of the nose, November 17, 1926.

PLATE 19

Further development of nasocutaneous form of gangosa in the same monkey as shown in Plate 18.

- FIG. 1. December 3, 1926.
2. January 2, 1927.

PLATE 20

FIG. 1. Well-developed gangosa. Same monkey as shown in Plates 18 and 19.

2. Same monkey as shown in fig. 1. The lesion is beginning to heal. Photograph taken one year later than the one shown in Plate 18, fig. 1.

PLATE 21

FIG. 1. Beginning caries of upper incisors as a consequence of gangosa. Same animal as shown in Plates 18, 19, and 20.

2. Multiple metastatic yaws lesions in the face of an experimental monkey.

PLATE 22

FIG. 1. Lupuslike scab forming lesions over the eyebrows. The primary lesion has entered the nose and healed in the skin but, following superinoculation on the right eyebrow, an ulcerative process developed on the septum of the nose. The septum was completely perforated when this photograph was taken.

2. The same monkey as shown in fig. 1. The ulcerative process is beginning to consume the ala nasi. Having entered the nose from the skin, it is destroying the facial part of the nose from inside out.

PLATE 23

FIG. 1. Well-developed case of the nasal form of gangosa.

2. Well-developed case of the nasocutaneous form of gangosa and keratoderma plantare in an experimental monkey.

PLATE 24

FIG. 1. Another case of the nasocutaneous form of gangosa.

2. Keratoderma plantare, the "moth-eaten skin" of the feet of the experimental monkey extending as ichthyotic dermatosis on the dorsum pedis.

PLATE 25

FIG. 1. A case of extensive gangosa of the nasocutaneous form.

2. Anatomical specimen of the case of gangosa in an experimental monkey, showing the excessive granulations and the swelling of the interior parts of the nose.

PLATE 26

Same case as Plate 25, fig. 1, after one injection of neosalvarsan.

PLATE 27

FIG. 1. A swelling between the eyebrows and on the right side of the nose, showing the character of immune reaction in yaws. The general marasmus and alopecia are also shown.

2. Specific swelling of the axillary glands and the right mamillary lymph gland in a case of generalized yaws.

PLATE 28

- FIG. 1. Section through an initial lesion of experimental yaw in the skin, showing the papule, and the accumulation of cellular infiltrate within the epidermis.
2. The type of cellular infiltrate in a well-developed yaws lesion surrounding a small blood vessel which remained normal.

PLATE 29

- FIG. 1. Section through gangosa, showing acanthosis and the presence of pigment cells in granulation tissue.
2. Section through turbinate of a case of gangosa, showing the superficial manner of spreading of the frambœsic process on the mucous membrane.

PLATE 30

- FIG. 1. *Treponema pertenue* in the intestine of a house fly, five hours after feeding on a frambœsic lesion.
2. Section through keratoderma plantare, showing acanthosis, hypertrophy of the epidermis, and keratosis. The subepidermal portion shows an accumulation of pigment cells but very little inflammatory reaction.

TEXT FIGURE

- FIG. 1. Diagram showing the results of superinfection and the continuous passage through monkeys of the Juan Cadangan strain of yaws. An asterisk indicates passage through monkeys without superinfection.



1



2

PLATE 1.



1



2

PLATE 2.



PLATE 3.



PLATE 4.



1



2

PLATE 5.



1



2





PLATE 7.



PLATE 8.



1



2



PLATE 10.



1



2



1



2

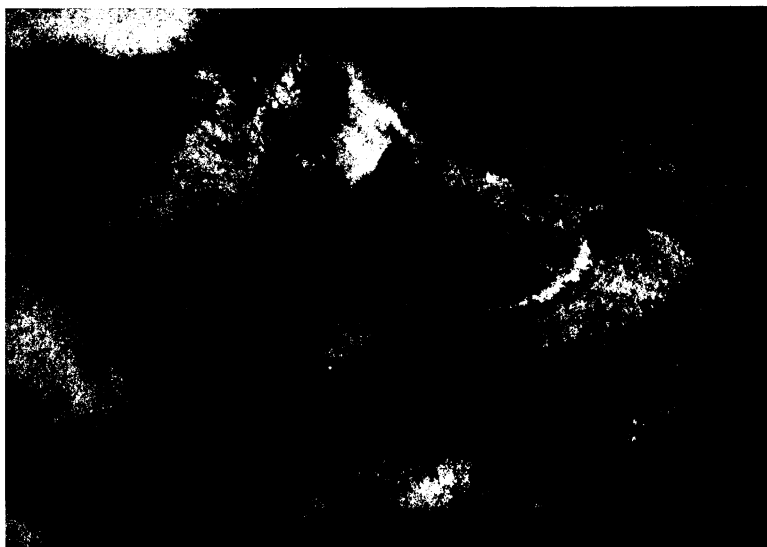




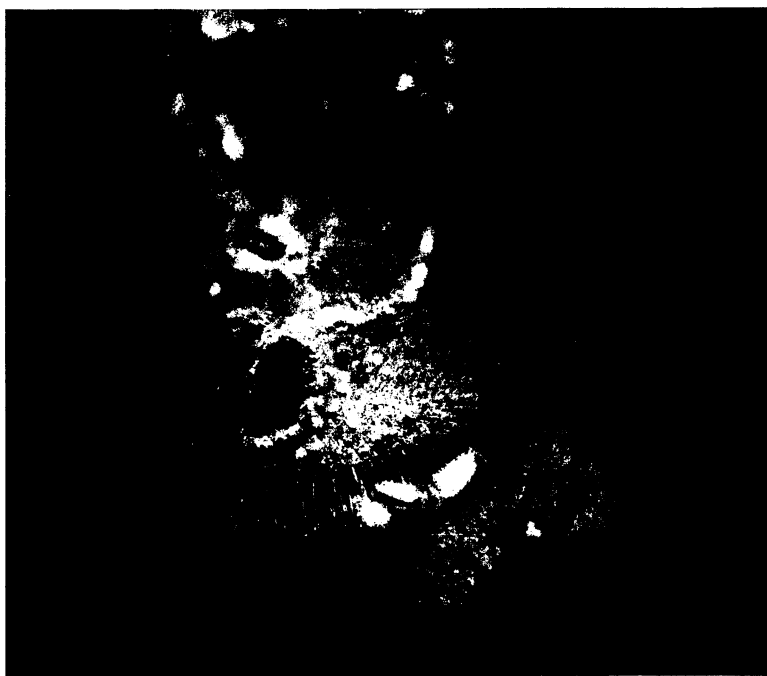
PLATE 13.



PLATE 14.



1



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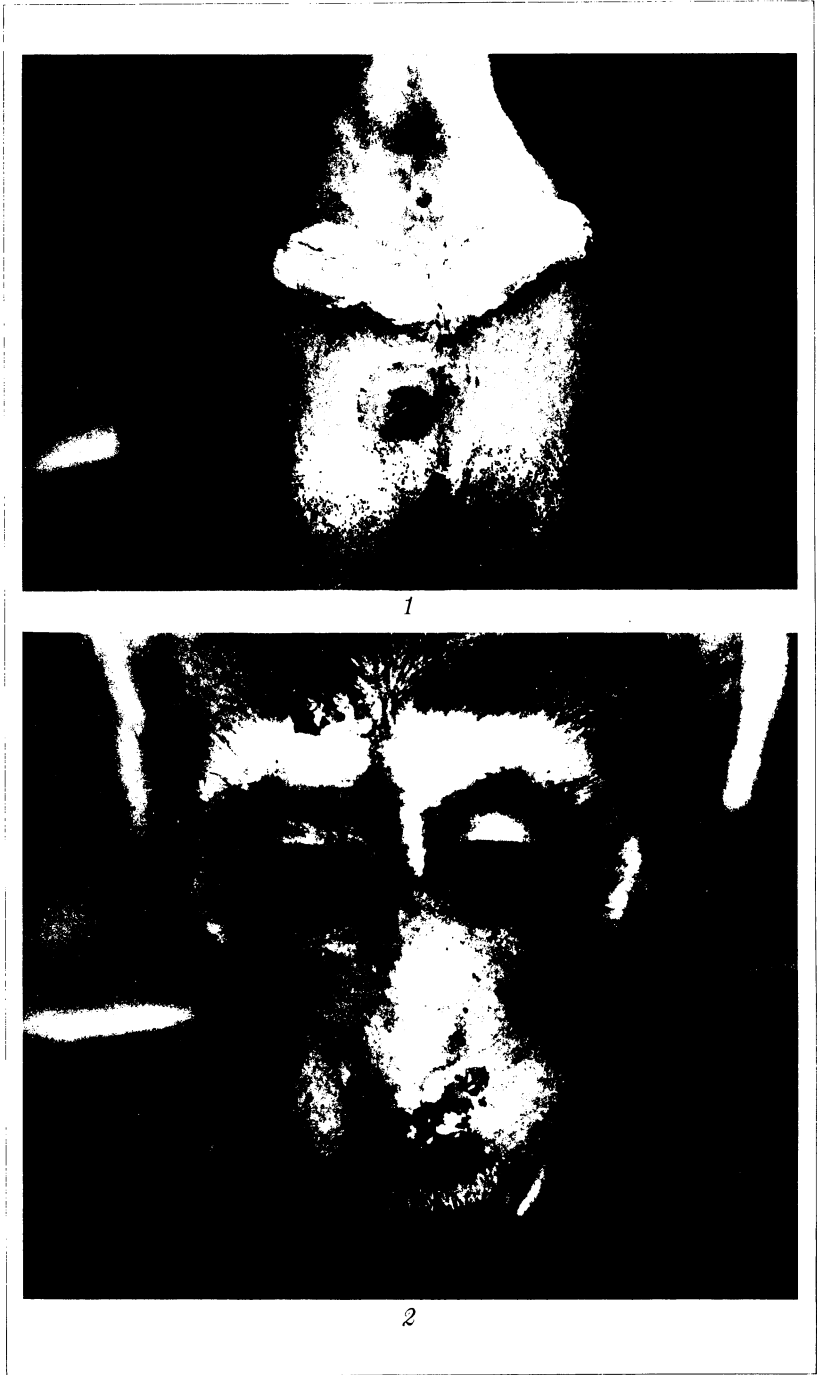


PLATE 16.



1



2



1



2



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2



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2



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2



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2



PLATE 26.



1



2





1



2



1



2





PLATE 30.

VIABILITY OF *TREPONEMA PERTENUE* OUTSIDE OF THE BODY AND ITS SIGNIFICANCE IN THE TRANSMISSION OF YAWS

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Up to the present and as far as the available references show, very little experimental work on the viability of either *Treponema pertenue* or *Treponema pallidum* has been done. There are fundamental differences between frambœsia and syphilis, as far as the possibilities of transmission are concerned. These differences become apparent from the following considerations:

1. Syphilis is a sexual disease, but frambœsia rarely becomes such and only secondarily.

2. The places of predilection of the primary lesion in syphilis are the mucous membranes; in frambœsia the place of predilection is the skin.

3. Syphilis is a disease that is acquired in the majority of cases after the age of puberty or it is inherited; but frambœsia is not hereditary and is contracted, in the great majority of cases and in endemic localities, before the age of puberty.

It becomes at once evident that the mode of transmission is not likely to be so uniform in yaws as in syphilis and, consequently, the study of viability of *Treponema pertenue* is of great importance in the epidemiology of this disease, and the result of such study may serve as a basis for the rational interpretation of the transmission of yaws.

In order to obtain some data with regard to the possible carriers of *Treponema pertenue* responsible for the transmission of the disease the experiments on viability of *Treponema pertenue* outside the body organism were extended to the study of its viability in or on the bodies of insects, some of which have been incriminated, and others might be, in the transmission of the disease.

As early as 1907 Ashburn and Craig(1) found active *Treponema* in yaws material kept in capillary tubes "for a period

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of several days." There is no indication found in their paper, however, that further experiments were performed by them on the viability of *Treponema pertenue*. Furthermore, I was unable to find any other reference on the subject in the available literature.

EXPERIMENTS ON VIABILITY OF TREPONEMA PERTENUE OUTSIDE OF THE BODY ORGANISM

The experiments here reported were performed with yaws material suspended in various liquids and exposed to room temperature (average 28.5° C.) for varying periods of time. The material was obtained from yaws lesions of experimental monkeys that had been infected with the strain Candangan for other purposes.

MICROSCOPIC EXAMINATION FOR MOTILE ACTIVITY OF TREPONEMA PERTENUE

The typical yaws lesion in monkey was scraped with a sterilized scalpel and the oozing serum, which contained a fair number of *Treponema pertenue*, was used. The microscopical examination was performed by means of dark-field illumination.

Several perfectly clean slides were prepared and a drop of physiological salt solution, or of normal horse serum, or of the serum of the experimental animal, was placed on each slide.

The yaws material was mixed with the drop of the medium on each slide by means of a scalpel; it was then covered with a cover glass and sealed by means of vaseline. Each slide was examined immediately after the sealing under dark-field illumination and only the slides that contained a fair number of active treponemas were kept for further observation.

DISCUSSION OF RESULTS

The motile activity of *Treponema pertenue* is not constant, not even in fresh material from the yaws lesion. Generally speaking, *Treponema pertenue* in the oozing serum from the early lesion is very active, but the treponemas found in an old and healing lesion are usually sluggish or nonmotile.

Although I failed by this arrangement of the investigation to determine the critical point of time when the motility of *Treponema pertenue* outside of the animal's body ceased, the length of time varying considerably in each experiment, yet the results give an indication of useful information as far as this problem is concerned. The initial motile activity of *Treponema pertenue* outside of the living body does not persist longer than three and

a half hours at room temperature. The medium in which the treponemas are suspended appears to be immaterial; that is, no striking difference was noticed whether physiological salt solution, horse serum, or the serum of the experimental animal was used.

However active the treponemas may be in the beginning of the experiment, the movement becomes sluggish within three and a half hours or less. The complete cessation of movement took place within not more than twenty-four hours and in not less than thirty minutes. The appearance of granules in the treponemas takes place after the movement has ceased. This seems to be the beginning of the morphological change in the micro-organism. The complete dissolution of the organism did not occur at times even after five days' exposure.

I am fully aware of the fact that the values as to the length of time during which *Treponema pertenue* can be detected or its motility noted outside of the body are not absolute and under various conditions they could probably not be duplicated, owing to the multiplicity of factors involved; but there is a strong indication that the treponemas, judging by their motility, survive but a comparatively short time.

In order to find out how far the immobilization of the treponemas can be taken as an indication of their death, a series of animal experiments was arranged in which the development or nondevelopment of the specific lesion following inoculation was used as an indicator of the viability of *Treponema pertenue*.

TECHNIC

Yaws material suspended in salt solution.—Several sterilized Petri dishes were prepared, each containing 0.5 cubic centimeter of sterilized physiological salt solution. The tissue of the lesion was scraped off with sterilized scalpel and emulsified in salt solution. Dark-field examination of this suspension was repeated and specimens containing treponemas were allowed to stand at room temperature. The suspension was injected into the experimental animal without further dilution at the end of definite periods of time.

The animal's own serum.—A number of sterilized capillary tubes were prepared. The oozing serum was collected into the capillary tubes. Both ends of the capillary tube were then sealed in the gas flame. Care was taken not to heat the material in the tube while sealing the tubes in the flame. The exposure of treponemas suspended in the lesion's own fluid was

made to approach natural conditions as nearly as possible. At the same time, sealing the tubes prevented evaporation and anærobic conditions were thereby achieved.

The capillary tubes were exposed to room temperature (25 to 28° C.), incubated at 37° C., or refrigerated at 0° C. for various periods of time. At the end of the exposure, just before the inoculation was made, both ends of the sealed capillary tubes were broken off and, by shaking gently, the content of the capillary tubes was emptied into sterilized Petri dishes containing, each, 0.5 cubic centimeter of physiological salt solution.

Series of experiments were performed as shown in Table 1. The temperature and the time of exposure of the material containing *Treponema pertenue* are recorded in the table.

TABLE 1.—Showing the results of the test for viability of *Treponema pertenue* outside of body organism.

[Experiment in vivo.]

Length of exposure to various temperatures.	Temperature to which exposed.	Suspended media of treponema.	Date of inoculation.	Result.	Date of appearance of lesion.	<i>Treponema pertenue</i> in the lesion.
	°C.					
Immediately.....	28	Salt solution	VII-9-26	+	IX-20-26	+
30 minutes.....	28	do	do.....	+	do.....	+
60 minutes.....	28	do	do.....	—		
2 hours.....	28	do	do.....	—		
19 hours.....	28	do	VIII-10-26	—		
22½ hours.....	28	do	do.....	—		
24 hours.....	28	do	do.....	—		
30 minutes.....	28	do	III-24-26	+	V-13-26	+
45 minutes.....	28	do	do.....	—		
2 hours.....	28	do	do.....	—		
30 minutes.....	5	do	IX-29-26	—		
Do.....	37	do	do.....	—		
1 hour.....	5	do	do.....	—		
Do.....	37	do	do.....	+	I-17-27	+
Immediately.....	28	Own serum	X-27-26	+	XII-14-26	+
30 minutes.....	28	do	do.....	+	do.....	+
1 hour.....	28	do	do.....	+	do.....	+
1½ hours.....	28	do	do.....	+	do.....	+
2 hours.....	28	do	do.....	—		
Immediately.....	28	do	XI-16-26	+	XII-14-26	+
30 minutes.....	28	do	do.....	+	do.....	+
1 hour.....	28	do	do.....	+	do.....	+
1½ hours.....	28	do	do.....	+	do.....	+
Immediately.....	28	do	XI-26-26	+	I-26-27	+
2 hours.....	28	do	do.....	+	do.....	+
2½ hours.....	28	do	XI-17-26	—		
4 hours.....	28	do	do.....	—		
1½ hours.....	37	do	I-24-27	+	III-10-27	+
Do.....	0	do	do.....	—		

TABLE 1.—Showing the results of the test for viability of *Treponema pertenue* outside of body organism—Continued.

Length of exposure to various temperatures.	Temperature to which exposed.	Suspended media of treponema.	Date of inoculation.	Result.	Date of appearance of lesion.	<i>Treponema pertenue</i> in the lesion.
	°C.					
Two hours.....	37	Own serum.....	I-24-27	+	III-23-27	+
Do.....	0	do.....	do.....	—		
Thirty minutes.....	37	do.....	II-3-27	—		
Do.....	0	do.....	do.....	—		
Six hours.....	28	Salt solution.....	XI-29-26	—		
Immediately.....	28	do.....	do.....	+	XII-29-26	+
One hour.....	37	Own serum.....	IV-11-27	—		
Do.....	0	do.....	do.....	—		
One and one half hours.....	37	do.....	do.....	+	VI-1-27	+
Do.....	0	do.....	do.....	—		
Three hours.....	0	do.....	IV-12-27	—		
Do.....	0	do.....	do.....	—		
Do.....	37	do.....	do.....	—		
Do.....	37	do.....	do.....	—		
Four hours.....	37	do.....	V-12-27	—		
Do.....	37	do.....	do.....	—		
Do.....	0	do.....	do.....	—		
Do.....	0	do.....	do.....	—		
Five hours.....	37	do.....	do.....	—		
Do.....	37	do.....	do.....	—		
Do.....	0	do.....	do.....	—		
Do.....	0	do.....	do.....	—		

Such animals as developed no sign of yaws were kept under observation for at least forty days before they were discarded. The inoculation of yaws material suspended in physiological salt solution and exposed to room temperature for thirty minutes resulted in a positive take. The same suspension of yaws material exposed to room temperature for forty-five minutes, for one hour, for two hours, for six hours, for nineteen hours, for twenty-two and one-half hours, and for twenty-four hours gave no takes.

Inoculation of yaws material kept in the donor's own serum and in sealed capillary tubes, when exposed to room temperature for thirty minutes, for one hour, for one and one-half hours, and for two hours, resulted in the development of yaws. Yaws material exposed for two hours, for two and one-half hours, and for four hours gave no takes.

The inoculation with yaws material suspended in physiological salt solution and exposed to body temperature (37° C.) for thirty minutes and for one hour produced yaws. The same material,

suspended in the same solution but exposed to a temperature of 5° C., gave negative results in both experiments with material exposed for thirty minutes and for one hour.

The experiments with the material suspended in the donor's own serum and kept in capillary tubes, when exposed to body temperature (37° C.) gave positive results after exposure of one hour, one and one-half hours, and two hours. Negative results were obtained in monkeys inoculated with the same material incubated at 37° C. when exposed for four hours and for five hours.

Inoculation of yaws material suspended in the donor's own serum and exposed to 0° C. for thirty minutes or more gave negative results without exception. The yaws material was kept in an electric refrigerator for thirty minutes, for one hour, for one and one-half hours, for two hours, for three hours, for four hours, and for five hours. From these experiments the conclusion can be drawn that *Treponema pertenue* remains viable at freezing point for less than thirty minutes.

The fact that *Treponema pertenue* does not survive at low temperature but, as shown in our experiment, dies in less than half an hour, I propose to offer as one (probably the main) factor responsible for the well-known fact that frambœsia tropica does not gain a foothold when introduced into a temperate climate. Cases are on record of frambœsia acquired by inhabitants of a moderate climate in the Tropics. Upon return of the patient from the Tropics to his homeland in a temperate climate, the disease ran its natural course, but no subsequent cases developed in his community.

Naturally, the factor given above is not the only one, and the different condition of the skin in the Tropics, due to high temperature and excessive humidity, from that encountered in the temperate climate, is another important factor that might also be responsible for the prevalence of yaws in hot countries and the nonexistence of frambœsia in cold countries. The modification of the clinical manifestation of yaws at high altitudes in the tropical Philippines has been brought out by Lopez-Rizal and Sellards. (8)

THE VIABILITY OF *TREPONEMA PERTENUE* IN AND ON INSECTS

Some of the fundamental points with regard to the viability of *Treponema pertenue* outside of the body organism having been ascertained, I extended my experiments to the problem of its viability in and on insects, in order to find some clue as to the

particular insect most likely to be responsible for the transmission of yaws. That the direct transmission of frambœsia from person to person is undoubtedly one of the ways of spreading and maintaining the disease has been conclusively demonstrated by experimental transmission of yaws from patient to animal or to man. That there is, however, more than one mode of transmission and that insects are the transmitters of the disease, has been generally suspected by workers in many tropical countries. Of all these insects, the fly has been most frequently incriminated, owing to its habits of feeding on secreting and oozing skin lesions.

According to Gudger,(4) the earliest reference as to the transmission of yaws bears date of 1769 from Guiana. The second, while of much later date (1817), indicates that in Brazil at that time the infection was conveyed by a certain fly recognizable by its small size. Walsh(14) published in 1831 an article in which he stated that the eye sometimes is partially affected and a small fly is then attracted by the discharge; this insect comes loaded with the contagious matter and communicates it to the next person on whose face it happens to light. Stedman(13) wrote in his description of the expedition to South America in 1796 as follows:

The yaws, * * * if a fly which has been feeding upon the disease (and they are generally covered with them) light upon the slightest scratch on a healthy person, it communicates this dreadful disorder, which always confines him for several months.

Kester(7) in 1817 described the transmission of yaws as follows:

This horrible disorder (the yaws) was contracted by inhabiting the same room with the patient, and by inoculation; this is effected by means of a small fly from which every precaution is often times of no avail; great numbers of the insects of this species appear in the morning, but they are not so much seen when the sun is powerful; if one of them chances to settle upon the corner of the eye or mouth, or upon the most trifling scratch, it is enough to inoculate the bobas, if the insect comes from a person who labors under the disease.

Robertson(11) in 1908 reported that he observed that a large number of flies infested the houses of natives suffering from yaws, and that they were in frequent contact with the prevalent secretions of the papules on the bodies of the inmates. In his second report (1910) Gudger(5) makes the following statement:

The yaws are * * *, and a small quantity of yellowish pus is usually seen adhering to their surface, which is commonly covered with flies, * * * it is usually believed that this disorder is communicated

by the flies which have been feasting on a diseased object, to those persons who have sores, or scratches, which are uncovered.

In 1911, Howard(6) stated that there is strong circumstantial evidence that tuberculosis, anthrax, yaws, etc., might be and were so carried. Castellani and Chalmers(3) in 1919 wrote as follows:

In our opinion there can be little doubt that in certain cases insects may carry the disease. It is very noticeable that flies eagerly crowd on the open sores of frambœsia patients.

Oho(10) in 1921 reported as follows:

In my investigation I was further able to ascertain that innumerable flies were sitting on the moist surfaces of the framboesic eruptions and that they sucked the secretion * * *; one finds in the habitations mostly *Musca domestica* and outdoors a yellow kind of fly *Musca xanthomera* (?). The last mentioned sucks with more zeal on small wounds, such as scratches and thereby produces pain, so that the primitives, who have for instance a small wound on the foot, cannot remain still (on account of the pain caused by the flies). This fly is possibly mostly to be blamed for the transmission of the infection.²

Some authors mention insects other than flies as responsible for the dissemination of yaws. Bahr(2) has suggested that the causative treponemas may be transmitted by some blood-sucking insect the range of which is definitely limited by the character of the vegetation or by climatic factors. Modder and Glas(9) concluded, from their yaws-inoculation experiments on birds, that the possibility of transmission of yaws by means of the argas and the ixodes varieties of tick could be easily demonstrated by any one who would try the experiment, because of the limitation of yaws to certain areas in Ceylon where these ticks are found. In the same paper the incubation period is given as six days. It is beyond our belief that a yaws lesion can be produced after so short an incubation period and that fowls are susceptible to frambœsia. There is, however, at present no experimental evidence to the contrary. Castellani and Chalmers(3) state that "Ants also are occasionally seen to go on to the framboetic ulcerations, as well as on to ordinary ulcers."

From the above-quoted references it is impossible to form a definite opinion as to whether or not insects are involved in the transmission of yaws and, if they are, which insects are responsible for the transmission.

² This quotation has been translated by Dr. O. Schöbl.

It is generally known that yaws is a household disease; that is, members of the same household are commonly infected. Furthermore, endemic villages are not unusual in the Philippine Islands.

The question of prevalence of yaws in the lowlands and its comparative rarity or absence in high mountains has been frequently discussed in the literature. A definite line of elevation has been drawn at 800 feet which has supposedly never been crossed by yaws. Oho,⁽¹⁰⁾ however, in Formosa, and Lopez-Rizal and Sellards⁽⁸⁾ in the Philippines, have demonstrated that frambæsia can be found at much higher altitudes than is generally believed. This geographic and climatic selectivity of yaws has been taken by Bahr⁽²⁾ as an indication that yaws is transmitted by special insects of similar geographic and climatic distribution. This explanation apparently does not consider the factor of viability of the causative agent, which was brought out in my researches. With regard to transmission, an experimental fact and a clinical observation must be considered. Lopez-Rizal and Sellards observed modification of the clinical yaws lesion at high altitudes; briefly stated, the yaws lesions were restricted among patients residing at high altitudes to warm moist folds and body orifices.

In my experiments the fact was brought out that *Treponema pertenue* outside of the body organism survives only a few hours and is so susceptible to low temperature that it becomes inert and can no longer produce a lesion when exposed to freezing temperature for even a few minutes, while at blood temperature it survives longer than at room temperature (average 28.5° C.). If the shortness of life of *Treponema pertenue* at low temperature be taken into consideration on one hand, and the modification of clinical yaws by low temperature at high altitude due to the condition of the skin on the other, it at once becomes evident that no particular insect restricted to this geographic distribution need be looked for as a carrier of yaws.

Indeed, common, geographically ubiquitous insects such as flies are more likely to be responsible for the transmission than is an insect of some particular geographic distribution. If the enormous numbers of treponemas discharged at times by the yaws lesions and the persistency with which flies feed on such oozing lesions as yaws be considered, then it becomes clear that a fly, of all insects hitherto accused, is most likely the one

responsible for the transmission of yaws. The disinclination of blood-sucking insects, such as bedbugs and mosquitoes, to feed directly on yaws lesions, and scarcity of *Treponema pertenue* in the circulating blood, must be considered.

EXPERIMENTS ON VIABILITY OF *TREPONEMA PERTENUE* ON AND IN THE BODY OF INSECTS

Such insects as were suspected to be responsible for the transmission of yaws were used in these experiments. House flies and mosquitoes were kept in special cages of a wooden frame and mosquito-net walls.⁽¹²⁾ The flies were fed on bananas and the mosquitoes on sugar water in the cages while awaiting the experiments. Bedbugs were kept in wooden boxes and maintained by feeding them on human blood. Immediately before the feeding experiment the insects were placed in sterilized individual test tubes which were then stoppered with cotton plugs.

The feeding of insects upon the yaws lesion was performed as follows: First of all, the crust was removed from the surface of the lesion and the presence of treponemas in the oozing liquid was ascertained. If the typical oozing did not take place immediately, this was provoked by gentle scratching of the surface of the lesion by means of a sterile scalpel. The lesion having been prepared in this manner, the particular insect, now confined in a sterile test tube, was selected. The test tube containing the insect was turned bottom up. The cotton plug was removed and the test tube was placed quickly over the lesion in such a manner that the mouth of the test tube was placed tightly on the surface of the lesion. By gentle tapping on the bottom of the test tube the insect was brought into direct contact with the surface of the lesion, where it could feed freely on the yaws material.

After the insect had fed it was killed by chloroform vapors or by crushing. The mouth of the test tube was sterilized by means of the gas flame.

The dead insect was placed in a sterilized mortar, crushed, and ground up, and the resulting pulp was suspended in 0.5 cubic centimeter of physiological salt solution.

In some instances the insects, after having been fed on yaws material, were dissected and the intestine alone, which was found to contain treponemas, was emulsified as described above.

The emulsion thus prepared was injected intradermally into normal monkeys.

DESCRIPTION OF PROCEDURE AND TECHNIC OF MICROSCOPIC
EXPERIMENTS

The dead insect that had fed on the yaws lesion was removed from the test tube and its legs and wings were removed. The body was then placed in the center of a microscopic slide. The slide was brought under the dissecting microscope and the body was divided by means of needles into three parts; namely, head, thorax, and abdomen. Each of the three parts of the insect's body was placed in a drop of normal saline solution on a separate slide. Then each part (that is, the head, the thorax, and the abdomen) was crushed with needles and the crushed part was transferred to another slide. Thus, two slides were prepared with the material obtained from the insect's head, two with that from the thorax, and two with that from the abdomen. One slide was examined immediately under the dark-field microscope; the other slide was stained by Fontana's method, slightly modified by me.

The results of the microscopic examination are given in Tables 2 to 4. During the feeding, the flies willingly started to take their meal from the lesion. Within three to five seconds the feeding had been accomplished. After this time they could not be induced to take more food from the oozing yaws lesion. It happened very often that mosquitoes, when they were induced to alight on a yaw, adhered to the moist surface of the lesion with their slender legs and consequently perished. They preferred naturally to suck blood on the normal skin through which they could easily introduce their sharp blood-sucking instrument (the proboscis). Accordingly, the mosquitoes that were subjected to the feeding experiment alighted, if at all, on the marginal part of the lesion only, and not on the lesion proper. It took thirty to fifty seconds before the abdomen bulged with blood. Bedbugs likewise refused to approach the dangerous moist surface of the yaws lesion; they sucked blood on the margin of the lesion, where the skin was dry. The feeding experiments with flies were successfully carried out without much difficulty, but those with mosquitoes ended with the result that only twenty-seven of the two hundred mosquitoes that were used in the experiments fed at all, and on the margin of the lesion at that.

TABLE 2.—Showing the results of microscopical examination of flies fed upon yaws lesions.

[+, positive finding; —, negative finding; 0, not done.]

Treponema in the lesion of the donor.	Time between feeding and microscopical examination.	Number and kind of flies examined.	Result of microscopic examination.					
			Head.		Thorax.		Abdomen.	
			Dark- field.	Fontana method.	Dark- field.	Fontana method.	Dark- field.	Fontana method.
+	Immediately.	2 house flies	—	—	—	—	++	+
+	do.	do.	—	—	—	—	++	—
+	do.	1 house fly	—	—	—	—	+	0
+	do.	1 bluebottle fly indirectly fed.	+	+	+	+	—	—
+	do.	1 house fly	+	—	+	—	—	—
+	do.	5 house flies	—	—	—	—	—	—
+	do.	3 bluebottle flies	—	—	—	—	—	—
+	Hrs. min.	1 house fly	—	—	—	—	—	—
+	0 10	1 bluebottle fly	+	0	—	0	+	—
+	0 30	1 house fly	—	—	—	—	—	—
+	0 40	do.	0	0	0	0	+	—
+	1 0	do.	—	0	—	0	+	+
+	1 30	2 house flies	—	0	—	0	++	—
+	1 45	1 house fly	—	0	—	0	+	—
+	2 0	do.	0	0	0	0	+	—
+	2 0	do.	—	0	—	0	—	0
+	2 10	do.	—	0	—	0	—	0
+	2 20	do.	0	0	0	0	+	+
+	2 30	do.	—	0	—	0	—	0
+	2 30	do.	—	0	—	0	+	+
+	3 10	do.	—	0	—	0	—	0
+	4 15	do.	—	0	—	0	+	+
+	4 40	do.	—	0	—	0	+	+
+	4 45	do.	—	0	—	0	+	—
+	5 50	do.	0	0	0	0	+	+
+	5 55	do.	0	0	0	0	+	+
+	6 45	do.	0	0	0	0	+	—
+	7 0	do.	—	0	—	0	—	0
+	7 15	do.	0	0	0	0	+	+
+	10 30	2 house flies	0	0	0	0	—	0
+	11 0	1 house fly	0	0	0	0	—	0
+	11 0	do.	0	0	0	0	+	+
+	23 0	2 house flies	—	0	—	0	—	0
Total		44 flies						
Positive			3	1	2	1	22	10

TABLE 3.—Showing the results of microscopical examination of mosquitoes (*Stegomyia fasciata*) fed upon yaws lesions.

[+, positive finding; —, negative finding; 0, not done.]

Treponema in the lesion of the donor.	Time between feeding and microscopical examination.	Mosquitoes examined.	Result of microscopic examination.					
			Head.		Thorax.		Abdomen.	
			Dark-field.	Fontana method.	Dark-field.	Fontana method.	Dark-field.	Fontana method.
+-----	Immediately.	4	—	0	—	0	—	0
+-----	do.	3	—	—	—	—	—	—
+-----	do.	3	0	0	0	0	+++	—
+-----	do.	1	0	0	0	0	+	—
+-----	Hrs. min.							
+-----	1 0	3	0	0	0	0	—	0
+-----	1 30	1	0	0	—	0	—	0
+-----	1 35	1	0	0	—	0	—	0
+-----	1 45	1	0	0	—	0	—	0
+-----	2 0	1	0	0	0	0	—	0
+-----	2 10	1	0	0	—	0	—	0
+-----	3 30	1	0	0	—	0	—	0
+-----	3 45	1	0	0	—	0	—	0
+-----	4 0	2	0	0	—	0	—	0
+-----	4 15	2	0	0	—	0	—	0
Total		25						
Positive							4	

TABLE 4.—Showing the result of microscopical examination of bedbugs fed upon yaws lesions.

[+, positive finding; —, negative finding; 0, not done.]

Treponema in the lesion of the donor.	Time between feeding and microscopical examination.	Bedbugs examined.	Result of microscopic examination.					
			Head.		Thorax.		Abdomen.	
			Dark-field.	Fontana method.	Dark-field.	Fontana method.	Dark-field.	Fontana method.
+-----	Immediately.	1	—	—	—	—	+	—
+-----	do.	1	—	—	—	—	—	+
+-----	do.	1	—	—	—	—	—	—
+-----	1 hour.	1	+	—	+	—	—	—
+-----	2 hours.	1	+	—	—	—	—	—
Total		5						
Positive			2		1		1	1

The experiment with bedbugs was practically a failure, because only five bedbugs out of more than fifty would feed on the lesion proper.

Textbooks of entomology state that blood-sucking insects such as mosquitoes and bedbugs suck blood by piercing the skin by means of their slender probosci which are provided with sharp tips and enter the capillaries of cutaneous tissue; the sucking action is caused by the blood pressure and by the capillary attraction through the probosci. It is unnatural for blood-sucking insects to feed on oozing blood or on the surface of a skin lesion, because such blood is devoid of pressure.

Flies have wide canals in the proboscis which are distended in the labella. The sucking is accomplished by the negative pressure which is produced by the action of a muscle around the proboscis.

Of the forty-four flies that were satisfactorily fed on the lesion of the donor, three flies contained treponemas in the head, two flies in the thorax, twenty-two flies in the abdomen, and two flies in both parts of head and thorax. Whenever the abdomen of a fly was found bulged with blood, it was possible to demonstrate treponemas microscopically in the intestine of the insect. Treponemas were demonstrated by dark field in the intestine of a housefly as long as eleven hours after feeding.

Of the total number of twenty-five mosquitoes that sucked the blood from the margin of the lesion and the abdomens of which were noted to be bulged with blood, four contained treponemas in the intestine.

Of the five bedbugs which sucked blood on the margin of the lesion of the donor, two contained treponemas in the head, one in the thorax, and one in the abdomen.

The results of our experiments with blood-sucking insects such as mosquitoes and bedbugs show that, if these insects can be induced to feed on the lesion, a high percentage become mechanical carriers of treponemas; but, in as much as observation teaches that these blood-sucking insects show a great disinclination to feed on yaws lesions, they do not enter as a serious factor in the indirect transmission of yaws.

ANIMAL EXPERIMENTS ON VIABILITY OF *TREPONEMA PERTENUE* IN AND ON INSECTS

It having been found that, of all the insects experimented with, house flies are most likely to be carriers of treponemas

in and on their bodies, the emulsion of the house flies that were fed on the yaws lesions was inoculated into monkeys. The results of these experiments are given in Table 5.

TABLE 5.—Showing the results of the test for viability of *Treponema pertenue* in and on insects.

Insect.	Part of insects used.	Time of exposure.	Treponema in the donor's lesion.	Date of inoculation.	Date of appearance of lesion.	Treponema in the lesion of the receiver.
House fly...	Entire body...	Immediately.	Few.....	XI-12-26	—	
Do.....	do.....	do.....	do.....	XI-15-26	—	
Bedbug.....	do.....	do.....	Fair number	do.....	—	
		Hrs. min.				
House fly...	Abdomen...	1	Numerous...	XI-26-26	—	
6 house flies.	Entire body...	20	Few.....	I-11-27	II-28-27+	+
3 house flies.	do.....	20	do.....	I-14-27	—	
4 house flies.	do.....	15	Fair number.	I-15-27	II-28-27+	+
Do.....	do.....	15	do.....	do.....	do. +	+
13 house flies	Intestine....	1	do.....	II-1-27	—	
5 house flies.	Entire body...	30	do.....	II-9-27	IV-2-27+	+

A monkey which received two inoculations with the material exposed in and on the fly's body for twenty minutes, gave a positive and a negative result, respectively. A monkey which received two inoculations with the material exposed on and in the fly for fifteen minutes, gave positive results from both. A monkey which received the material exposed for thirty minutes, gave positive results. From these experiments, it is clear that treponemas survive in and on the body of the house fly for thirty minutes. In other words, *Treponema pertenue* survives on and in the body of the flies about the same length of time as it does in physiological salt solution.

Transmission experiments of yaws to monkeys, by flies fed on the lesion, were performed by Castellani and Chalmers(3) and their coworkers prior to my experiment. The details are given as follows:

One of us made some experiments to prove that flies are instrumental in the dissemination of the disease. A number of flies were fed on scrapings from slightly ulcerated framboetic papules. * * * On examination after feeding, the majority presented coarse spirochætes, and a few of them also *T. pertenue*. In another experiment flies fed on yaws material were placed on scarified spots over the eyebrows of several monkeys, and kept there for two hours by means of strips of gauze smeared with colodion at their margins. One of the monkeys became infected.

CONCLUSIONS

1. Up to a certain limit the so-called motility of *Treponema pertenue* can be used as an indication of its viability.
2. The viability of *Treponema pertenue* outside of the body proved to be of short duration.
3. The temperature of the human body (37° C.) proved to be more favorable to the survival of *Treponema pertenue* than did room temperature (average 28.5° C.).
4. At low temperature (0 to 5° C.) the period of viability of *Treponema pertenue* is very limited (less than thirty minutes).
5. The period of viability on and in the body of flies is short.
6. The inability of *Treponema pertenue* to survive at low temperature is given as one of the factors responsible for the fact, that, when introduced into a cold country, yaws will not gain a foothold.

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AN INVESTIGATION TO DETERMINE A SATISFACTORY STANDARD FOR BERIBERI-PREVENTING RICES *

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TWO PLATES AND EIGHT TEXT FIGURES

I. THE METHOD EMPLOYED

Although medical authorities still differ with regard to a number of details concerning the etiology of beriberi, there is a very general consensus of opinion to the effect that beriberi is a deficiency disease, produced whenever, in the absence of an adequate mixed diet, highly milled rice is used as the main food staple, and that the disease can be prevented by the substitution of a sufficiently undermilled rice. The most striking illustration of this fact with which we are familiar is the case of the Philippine Scouts. For a number of years (1902-1909), while they were supplied with the best grade of highly milled rice, beriberi was the most important cause of admission to sick report for these native troops, the incidence often reaching as high as 10 per cent of the entire number (5,000). In 1910 the substi-

* Read at the seventh congress of the Far Eastern Association of Tropical Medicine, Calcutta, India.

tution of undermilled rice was made. Beriberi at once declined as a cause of admission and at the end of a year, when the substitution had been made universally effective, beriberi was completely eradicated. Since that time undermilled rice only has been furnished, and during all these years beriberi has completely ceased to appear among these troops, although they were living in the midst of a population where beriberi is very common. Similar results have been obtained in a number of civil institutions in the Philippines as well as in other countries.

Such experiences led several sanitary authorities to recommend legislation by the various countries most concerned, which would diminish the production or importation of highly milled rice; but it was promptly realized that no such law could be administered without a satisfactory legal standard for beriberi-preventing rices.

Fraser and Stanton originally recommended a standard of 0.4 per cent phosphorus pentoxide, and for a long time this standard was supposed to be satisfactory. Later observations, by Schüffner and Kuenen,⁽¹⁾ and McCarrison and Norris⁽²⁾ and others have shown clearly that a number of rices containing 0.4 per cent or more may produce beriberi. Schüffner and Kuenen⁽¹⁾ stated that rice should contain at least 0.5 per cent phosphorus pentoxide. It is unnecessary to dwell on this point, for all will agree that up to the present time no satisfactory standard has been established.

The resolution passed by the Far Eastern Association of Tropical Medicine in its 1925 meeting included statements to the effect that nothing has occurred to controvert the disappearance of beriberi when an adequate diet is used; that the governments concerned should encourage research toward developing a practical test to distinguish between rices that may cause beriberi and rices that may prevent beriberi when used as a staple of diet; and that facts be collected which may be used in classifying rice in its different stages in the process of milling.

Beriberi cannot be eradicated without legislation in the countries in which it is endemic, and legislation waits on the determination of a satisfactory standard for beriberi-preventing rices. Therefore, when one of us was assigned to the United States Army Medical Department Research Board at Manila, it appeared that this was the most important problem connected with beriberi awaiting solution. Work was commenced in October, 1925, and was continued without interruption until October, 1927.

Plan of the work.—It was determined to procure series of two hundred samples of rice, grown in different localities and of all degrees of milling. These rices were to be inspected to determine the percentage of the external layers of the grain still adhering to them, and were to be submitted to chemical analysis. At the same time they were to be fed to pigeons to determine their actual beriberi-producing potentialities. The chemical analyses and the feeding experiments were to be carried on independently, and the results so obtained subsequently combined. The actual details of this simple plan are given fully, in order that there may be no question as to how the results were obtained.

1. Procurement of rice samples.—Twenty samples were purchased in the open market. These samples were all machine-milled, but came from widely separated localities (three were from China), and the degree of milling was by no means uniform.

Twelve rices were secured from the Quartermaster of the United States Army. Seven were samples of undermilled rice furnished the Philippine Scouts and five were samples of choice, highly milled rice. Each sample was from a different purchase by the Quartermaster from wholesale dealers.

Samples 10 to 15, inclusive, were obtained as follows: Two different varieties of unhusked rice (palay) were taken to a primitive mill in which the milling of rice was carried on by water power. As the water wheel revolved it lifted heavy pestles which were later released and fell into stone mortars. Both of these samples of rice were submitted to this milling action for varying periods of time. The sample first removed (No. 1) was undermilled, that removed next (No. 2) was more completely milled, and the third and last (No. 3) was highly milled white rice. By consulting the tables it will be seen that both samples of rice, when undermilled, prevented the appearance of polyneuritis when fed to pigeons, and that polyneuritis occurred with both samples when highly milled.

Ten samples of rice (palay) were sent to us from Java, through the courtesy of General H. M. Neeb and Dr. P. J. S. Cramer, director of the Experiment Station, Department of Agriculture, Java. These samples were hand-pounded in Manila, thus receiving different degrees of polishing.

The remaining one hundred fifty-two samples were procured for us by Dr. Stanton Youngberg, director of the Bureau of

Agriculture of the Philippines. These samples of many different varieties of rice were procured from various islands and provinces of the Philippines, and were all hand-pounded, so that no two rices were precisely similar in degree of milling. We wish here to express our obligation to Doctor Youngberg. Without his cordial and continued coöperation, it would have been impossible to obtain such a large series of different rices.

Ten kilograms of each sample of rice were purchased. The rice was kept in tightly covered tin cans in a dry storeroom, and each can labeled with the serial number of the rice. As experience promptly showed that weevils, moths, and other insects developed in rice so kept, a vial of chloroform with a loose stopper was buried in each sample. The escaping vapor promptly killed all insects, and the rices kept in this manner remained in good condition during the one hundred days that the experiment lasted.

2. *Inspection for pericarp.*—One hundred grains of rice, taken at random, were stained with Gram's iodine solution for one minute, after which the iodine was rinsed off with water. Each grain was then examined, and the amount of pericarp remaining was expressed as a percentage, the whole pericarp with the rice embryo intact representing 100 per cent. This method appears very rough and inaccurate, yet long experience in selecting undermilled rices for the Philippine Scouts had demonstrated the fact that it is possible in this way to pick out invariably a grade of rice that will prevent beriberi. The results of this inspection are included in Table 1.

3. *Chemical analyses.*—The antineuritic vitamin is undoubtedly chiefly contained in the embryo and the aleurone layer of the rice grain. The outer layer, the pericarp, contains a high percentage of mineral matter, and if most of the pericarp is retained the embryo is often also present. The majority of the fat of the grain occurs in the aleurone layer. For these reasons, the chemical estimation of mineral salts (ash) or fat might be as good an index as phosphorus pentoxide, which was chosen only because the phosphorus of the grain is also chiefly contained in these external layers. None of these substances is chemically related to the antineuritic vitamin, which contains no phosphorus, fat, or mineral salts. This vitamin, however, is a nitrogenous compound and, in the absence of any direct chemical test or satisfactory color reaction for its precise quantitative

estimation, there was a possibility that amido-nitrogen content might prove to be a good chemical index.¹ Total nitrogen is valueless because the protein of rices varies considerably, irrespective of the vitamin content. The methods used (Feliciano) were as follows:

(1) *Moisture*.—Determined by drying a known weight of sample (5 grams) in an electric oven at 100 to 105° C. until a constant weight was obtained. The loss of weight represents the moisture present.

(2) *Ash*.—Ash was determined by properly incinerating the dried sample from the moisture determination. The weight of the white or gray residue, free from carbon, represents the ash content.

(3) *Fat*.—Fats were determined by extracting a weighed sample of dried, finely powdered rice with pure ether in a Soxhlet apparatus for forty-eight hours. The extract was freed from ether and moisture, and weighed. This result was checked by drying the extracted rice and finding the loss in weight.

(4) *Phosphorus pentoxide*.—One gram of the sample is carbonized in a porcelain dish. Add 0.2 to 0.4 gram magnesium nitrate. Ash until white. Place the dish containing the ash in a beaker of 400 cubic centimeters and add a sufficient quantity of concentrated nitric acid, immediately followed by distilled water. Heat until solution is obtained. Neutralize the acid with ammonia, then add two or three drops of concentrated nitric acid. Add 25 cubic centimeters of the molybdic acid solution. Stir to induce precipitation, and let stand in a warm place at about 40° C. overnight. Filter through purified asbestos, wash thoroughly with cold water until free from acid, then transfer back to original beaker. Add 50 cubic centimeters distilled water and 40 cubic centimeters N/10 sodium hydroxide. Heat until precipitate is completely dissolved. Titrate back excess sodium hydroxide with N/10 sulphuric acid using phenolphthalein as indicator. Calculate as phosphorus pentoxide.²

(5) *Nitrogen*.—Nitrogen was determined by Gunning's modification of Kjeldahl's method.

¹ This was originally suggested by Chamberlain, Vedder, and Williams in, A third contribution to the etiology of beriberi, Philip. Journ. Sci. § B 7 (1912) 39.

² See Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists, page 2.

(6) *Amido-nitrogen*.—Albuminoid nitrogen is determined, and subtracted from the total nitrogen to obtain the amido-nitrogen.

(7) *Albuminoid nitrogen*.—Place 0.7 gram of the sample in a beaker. Add 100 cubic centimeters water, and heat in a steam bath for ten minutes; add a quantity of cupric hydroxide reagent containing about 0.5 gram of the hydroxide; stir and filter when cold; wash with cold water, and without removing precipitate from filter determine the nitrogen by Gunning's modification of the Kjeldahl method. The filter paper used must be free of nitrogen.³

All results were calculated on the original weight of the rice rather than on the dry weight, because this is the method in general use in determining the phosphorus pentoxide content of rices submitted for routine analysis, since rice is not sold or consumed by dry weight. However, the percentages by dry weight were calculated for a considerable number of the rices in the hope that this more accurate method would reduce the number of rices producing irregular results. It was found that there was no significant difference in the ultimate results, whether calculations were made on original weight or on dry weight.

4 *Feeding experiments*.—Pigeons were selected for feeding, because they are even more susceptible to polyneuritis than fowls and are readily handled. Four pigeons were fed upon each sample of rice, allowing them all that they would eat. A jar of water was in each cage, but no other food was given or was obtainable by the birds. The birds were fed and observed daily by one of us (Vedder), and the date on which each bird first developed symptoms of polyneuritis was observed and entered in a notebook. The bird was watched until it became obviously paralyzed, often with retraction of the neck. When thus on the point of death, the bird was treated by administering small amounts of rice polishings (tikitiki) or an extract of the same. Prompt recovery after this treatment was almost invariable and confirmed the original diagnosis of polyneuritis (Plate 1). In cases of death without obvious symptoms of polyneuritis, a post-mortem examination was made to determine the cause of death, and the sciatic nerves were removed and stained by the Marchi method to determine the existence of degeneration. In any case in which the results of this feeding experiment could be con-

³ Op. cit., Chapter IX, pars. 9 and 10.

sidered doubtful, because of loss of birds from intercurrent disease or for other reasons, the experiment on that rice was repeated with a new group of birds. Therefore, nearly nine hundred birds were used.

The pigeons under experiment were confined in groups of four, in a series of fifty-six wire cages 36 by 36 by 30 inches, placed upon a concrete foundation, and covered by a galvanized-iron roof. Each cage was numbered and provided with a bamboo roost and a similarly numbered wooden box to hold the rice. The cages (shown in Plate 2) were ideal for the experiment and were specially constructed by the Bureau of Science for this purpose. We desire here to express our obligation to Dr. William H. Brown, the director of the bureau, for providing us with these cages, and for facilitating the work in every possible way.

In estimating the beriberi-producing potentiality of a rice there are two factors to be considered; namely, the number of individuals that develop the disease, and the rapidity of development of the disease. An attempt has been made to express both of these factors in a single figure called the beriberi-producing factor. The number of birds that developed beriberi was expressed as the percentage of the total number used in the experiment, and this percentage was divided by the average number of days elapsing from the time the rice was first fed until the first symptoms of polyneuritis appeared. Thus, the higher the percentage of the birds that developed beriberi, and the shorter the depletion period, the greater does this beriberi-producing factor become.

Pigeons may occasionally develop polyneuritis as early as fifteen days on a very deficient rice. If none of the four birds developed polyneuritis after one hundred days of feeding, it was assumed that the rice afforded sufficient protection, and the experiment was discontinued. In this connection it may be emphasized that, as pigeons are far more susceptible to polyneuritis than is the human race to beriberi, it may reasonably be claimed that any rice that protects pigeons from polyneuritis for one hundred days will prevent the appearance of beriberi in man, even when used as an exclusive diet, which is seldom the case.

The results of this work, including the chemical analyses of each rice, with the effect of feeding to fowls, are presented in Table 1. The figures for each chemical ingredient were also

TABLE 1.—Chemical analyses of various rices and results of feeding same to pigeons.

No.	Name.	Locality.	Pericarp remaining.	Chemical analysis.						Result of feeding.		
				Mois- ture.	Fat.	Phos- phorus pentox- ide.	Ash.	Total.	Nitro- gen.	Amido- nitro- gen.	Beri- beri.	Beri- beri fac- tor.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
1	B.	Nueva Ecija	10	0.72	0.39	0.61	1.72	1.27	0.18	50	0.96	
2	No. 2 red.	Pampanga	60	1.37	0.59	0.91	2.87	1.02	0.38	0	0	
3	H.	Nueva Ecija	0	0.70	0.31	0.70	1.71	1.12	0	50	1.10	
4	B.	Tarlac	8	0.77	0.42	0.85	2.04	1.03	0	100	1.92	
5	A.	Pangasinan	10	0.71	0.45	0.71	1.87	1.16	0	75	1.78	
6	No. 1 red.	Pampanga	15	0.71	0.47	0.89	2.07	1.10	0	75	1.50	
7	Magalang red.	do.	5	0.82	0.40	0.60	1.82	1.05	0.55	75	1.59	
8	Scout rice.	Pangasinan	95	1.84	0.73	1.13	3.70	1.14	0.43	0	0	
9	Choice rice	Pampanga	0	0.30	0.25	0.35	0.90	1.23	0.05	100	4.00	
10	Apostol No. 1.	Laguna	90	1.64	0.66	1.19	3.49	1.05	0.02	0	0	
11	Apostol No. 2.	do.	24	1.03	0.53	1.04	2.60	1.09	0.01	25	0.03	
12	Apostol No. 3.	do.	10	0.50	0.39	0.64	1.53	1.03	0.12	100	3.03	
13	Mangasa No. 1.	do.	95	1.74	0.69	1.27	3.70	1.17	0.14	0	0	
14	Mangasa No. 2.	do.	80	1.18	0.58	1.05	2.81	1.16	0.12	0	0	
15	Mangasa No. 3.	do.	5	0.49	0.36	0.72	1.57	1.09	0.04	100	3.47	
16	Choice rice	Pampanga	0	0.54	0.33	0.50	1.37	1.00	0.16	100	3.70	
17	do	do.	0	0.54	0.39	0.50	1.43	1.13	0.04	100	1.75	
18	do	do.	95	1.35	0.56	0.88	2.79	1.14	0	0	0	
19	Scout rice.	Tarlac	5	0.81	0.44	0.60	1.85	1.12	0.05	100	2.56	
20	AX	do.	5	0.94	0.39	0.63	1.96	1.03	0	100	2.56	
21	No. 2 red.	do.	90	1.76	0.55	1.08	3.39	1.14	0.12	0	0	
22	Inantipolo.	Rizal	85	1.07	0.55	0.82	2.44	0.98	0	0	0	
23	Manabunac.	do.	10	0.94	0.47	0.76	2.17	0.93	0.01	75	2.56	
24	Binankero.	do.	10	1.04	0.46	0.75	2.25	1.05	0.02	100	1.85	
25	Scout rice	do.	95	2.69	0.78	1.20	4.67	1.23	0.05	0	0	

TABLE 1.—*Chemical analyses of various rices and results of feeding same to pigeons—Continued.*

No.	Name.	Locality.	Pericarp remain- ing.	Chemical analysis.						Result of feeding.		
				Mois- ture.	Fat.	Phos- phorus pentox- ide.	Ash.	Total.	Nitro- gen.	Amido- nitro- gen.	Beri- beri. P. ct.	Beri- beri fac- tor.
61.	Dinagupan.....	Nueva Ecija.....	P. ct. 15	12.48	0.78	0.48	0.64	1.90	---	---	100	1.85
62.	Macan cumpul.....	do.....	50	11.74	1.37	0.60	0.96	2.93	---	---	0	0
63.	Mimis.....	do.....	15	12.69	0.67	0.59	0.83	2.09	---	---	50	1.04
64.	Minanteca.....	do.....	25	11.91	0.77	0.61	0.87	2.25	---	---	75	1.12
65.	Macan neining.....	do.....	16	11.54	0.91	0.52	0.86	2.29	---	---	75	0.91
66.	Minalabon.....	do.....	10	12.37	0.91	0.47	0.69	2.07	---	---	75	0.73
67.	Saigon.....	do.....	25	12.14	1.20	0.57	0.80	2.57	---	---	0	0
68.	Macan.....	Laguna.....	90	11.74	2.06	0.73	1.21	4.00	---	---	0	0
69.	Kinanda.....	do.....	90	12.34	1.47	0.74	1.11	3.32	---	---	0	0
70.	Magsalit.....	do.....	87	12.07	2.02	0.73	1.30	4.05	---	---	0	0
71.	Binerto.....	do.....	95	11.52	2.39	0.77	1.17	4.33	---	---	0	0
72.	Mangasa.....	do.....	90	11.97	1.84	0.76	1.26	3.86	---	---	0	0
73.	Sinanguing.....	do.....	96	11.96	2.16	0.63	1.19	3.98	---	---	0	0
74.	Guinangang.....	do.....	90	12.60	1.72	0.69	1.22	3.63	---	---	0	0
75.	Sinan Jose.....	do.....	87	12.08	1.89	0.62	1.30	3.81	---	---	0	0
76.	Dinagat.....	do.....	88	12.43	2.14	0.71	1.28	4.13	---	---	0	0
77.	Sinadyaya.....	do.....	89	12.32	1.76	0.64	1.28	3.68	---	---	0	0
78.	Sinandaang.....	do.....	98	11.59	1.80	0.58	1.09	3.47	---	---	0	0
79.	Piniro.....	do.....	80	12.59	1.74	0.63	1.25	3.62	---	---	0	0
80.	Kalibo.....	do.....	86	11.92	1.87	0.64	1.16	3.67	---	---	0	0
81.	Scout rice, QMC.....	Pampanga.....	92	11.08	1.79	0.76	1.18	3.73	---	---	0	0
82.	Magsanbay.....	Laguna.....	88	11.81	2.20	0.86	1.40	4.46	---	---	0	0
83.	Piniro.....	do.....	89	12.40	2.35	0.82	1.24	4.41	---	---	0	0
84.	Kalibo.....	do.....	85	12.94	1.87	0.76	1.33	3.96	---	---	0	0
85.	Mangasa.....	do.....	90	12.40	2.06	0.82	1.40	4.28	---	---	0	0

86	Binrhen	do.	91	12.03	2.03	1.79	1.38	4.20	0	0
87	Kinaba	do.	92	11.88	1.94	0.78	1.31	4.03	0	0
88	Pino	do.	93	11.25	2.77	0.88	1.40	5.05	0	0
89	Tiniaong	do.	92	12.25	2.31	0.68	1.21	4.20	0	0
90	Binagat	do.	90	12.59	2.31	0.73	1.29	4.33	0	0
91	Pulapot	do.	88	12.19	2.16	0.80	1.28	4.24	0	0
92	Choice rice, QMC	Rizal	3	11.30	0.67	0.47	0.56	1.70	100	2.08
93	Bulao	Negros	10	11.77	0.26	0.55	0.67	1.48	100	1.93
94	Cababag	do.	14	11.99	0.41	0.43	0.55	1.39	100	2.68
95	Tuhao	do.	9	12.75	0.31	0.38	0.54	1.23	100	2.94
96	Mayoro	do.	9	11.89	0.29	0.35	0.57	1.21	100	2.56
97	Bagonhon	do.	10	12.31	0.39	0.53	0.78	1.70	100	2.04
98	Inantipolo	do.	8	12.64	0.61	0.50	0.68	1.79	75	1.21
99	Cabunlay	do.	10	11.93	0.41	0.53	0.76	1.70	100	1.62
100	Dalikat	Laguna	90	10.86	1.78	0.85	1.39	4.02	0	0
101	Dinagat	do.	90	11.09	2.34	0.75	1.29	4.38	0	0
102	Inintiw	do.	90	11.87	2.25	0.89	1.41	4.55	0	0
103	Inabaca	do.	90	11.08	1.79	0.86	1.38	4.03	0	0
104	Intilog-dalog	do.	88	11.18	2.26	0.85	1.29	4.40	0	0
105	Kinaba	do.	91	11.19	2.28	0.83	1.36	4.47	0	0
106	Magsampay	do.	90	10.65	1.58	0.82	1.39	3.79	0	0
107	Pino	do.	90	11.58	2.86	0.82	1.90	3.58	0	0
108	Pinro	do.	90	11.29	2.34	0.81	1.26	4.41	0	0
109	Tiniaong	do.	95	11.27	2.37	0.82	1.34	4.53	0	0
110	Melmel	Nueva Vizcaya	25	12.53	0.75	0.55	0.80	2.10	75	1.37
111	Langay	do.	10	12.11	0.93	0.57	0.89	2.39	75	1.07
112	Daluson	do.	50	11.87	1.29	0.58	0.94	2.81	0	0
113	Santo Tomas	do.	20	12.79	0.92	0.51	0.87	2.30	75	1.26
114	Maraliza	do.	50	11.82	1.30	0.60	1.14	3.04	0	0
115	Tritter	do.	15	12.52	0.75	0.43	0.81	1.99	75	1.10
116	Mabolo	do.	75	12.52	1.49	0.62	1.08	3.19	0	0
117	Ganado	do.	30	11.88	1.27	0.48	0.66	2.41	50	0.64
118	Mambaboring	do.	24	11.92	0.99	0.51	0.75	2.25	75	1.05
119	Monson	do.	45	12.12	1.27	1.58	0.86	2.71	0	0
120	Gindao	Leyte	38	7.42	1.37	0.62	1.06	3.05	0	0

TABLE 1.—Chemical analyses of various rices and results of feeding same to pigeons—Continued.

No.	Name.	Locality.	Pericarp remaining.	Chemical analysis.						Result of feeding.		
				Moisture.	Fat.	Phosphorus pentoxide.	Ash.	Total.	Nitro-gen.	Amido-nitro-gen.	Beri-beri.	Beri-beri fac-tor.
121	Biribon.	Leyte.	P. ct. 85	P. ct. 6.07	P. ct. 2.17	P. ct. 0.74	P. ct. 1.20	P. ct. 4.11	P. ct.	P. ct.	0	0
122	Porikit.	do.	40	8.44	1.18	0.66	1.14	2.98			0	0
123	Cabting.	do.	50	8.40	1.55	0.81	1.38	3.74			0	0
124	Misamis.	do.	77	7.08	1.36	0.84	1.54	3.74			0	0
125	Kinutong.	do.	66	9.79	1.52	0.56	1.02	3.10			0	0
126	Kinanpay.	do.	75	8.70	1.53	0.74	1.21	3.48			0	0
127	Agitpay.	do.	20	7.39	1.24	0.66	1.10	3.00			0	0
128	Cabud-bud.	do.	90	6.71	1.92	0.91	1.88	4.71			0	0
129	Lubane.	do.	80	6.48	1.56	0.58	1.06	3.20			0	0
130	Bungkol.	Ilocos Norte.	30	10.00	1.07	0.51	0.82	2.40			0	0
131	Malikat.	do.	10	9.92	0.88	0.51	0.56	1.95			50	1.91
132	Dalusan.	do.	5	9.94	0.99	0.45	0.66	2.10			100	1.41
133	Begsang.	do.	75	9.85	1.90	0.77	1.20	3.87			0	0
134	Capitana.	do.	20	9.96	1.21	0.54	0.87	2.62			75	1.41
135	Mudson.	do.	25	9.71	1.17	0.56	0.83	2.56			0	0
136	Macablag.	do.	20	10.78	1.13	0.55	0.86	2.54			0	0
137	Tenido.	do.	5	9.70	0.88	0.51	0.73	2.12			100	2.22
138	Galiano.	do.	55	9.78	1.54	0.71	1.05	3.30			0	0
139	Tadioc.	do.	50	9.65	1.26	0.57	0.87	2.70			0	0
140	Kinastano.	Batangas.	15	10.23	0.92	0.56	0.78	2.26			25	0.32
141	Inabaka.	do.	10	10.20	0.76	0.53	0.69	1.98			0	0
142	Binagat.	do.	12	10.32	0.84	0.54	0.94	2.32			100	1.58
143	Pinursige.	do.	50	9.74	1.11	0.53	0.83	2.47			0	0
144	Nagdame.	do.	20	9.39	1.00	0.55	0.80	2.35			0	0
145	Kinawayan.	do.	40	9.94	0.99	0.58	0.89	2.46			25	0.31

146	Aguyod	do.	30	9.70	1.27	0.53	0.90	2.70	0	0
147	Tampukoy	do.	20	9.93	1.04	0.53	0.79	2.36	0	0
148	Kinandang pute.	do.	10	9.78	0.59	0.51	0.83	1.93	75	1.34
149	Kinandang pula.	do.	40	10.07	0.96	0.63	1.07	2.66	0	0
150	Scout rice, QMC.	Pampanga.	88	12.52	1.36	0.76	1.07	3.19	0	0
151	Cotsian	Iloilo.	33	10.62	1.15	0.54	0.67	2.36	0	0
152	Calubad	do.	28	8.94	0.99	0.56	1.03	2.58	25	0.71
153	Cabonlong	do.	35	9.21	1.12	0.57	0.98	2.61	75	1.83
154	Eninian	do.	25	9.85	1.15	0.56	0.97	2.68	25	0.39
155	Macan arabon	do.	10	10.71	1.10	0.60	0.70	2.40	25	0.96
156	Macan quinata	do.	75	9.58	1.40	0.59	1.00	2.99	0	0
157	Macan kinalway	do.	30	10.72	1.09	0.62	0.97	2.68	0	0
158	Tahao	do.	45	9.62	1.68	0.66	0.95	3.29	0	0
159	Macan tabao	do.	75	11.08	1.32	0.65	1.09	3.06	0	0
160	Hinipon	do.	12	10.16	1.06	0.55	0.71	2.32	25	0.27
161	Magsalit	Bulacan.	55	11.32	1.80	0.71	1.03	3.54	0	0
162	Macan puti	do.	65	10.40	1.84	0.54	1.16	3.54	0	0
163	Macan Obando	do.	45	10.75	1.83	0.68	1.04	3.55	0	0
164	Macan tago	do.	40	10.72	1.49	0.65	0.89	3.03	0	0
165	Macan cumpul	do.	45	11.60	1.39	0.63	0.94	2.96	0	0
166	Dinunero	do.	95	10.68	1.86	0.71	0.78	3.35	0	0
167	Tinacloban	do.	35	9.95	1.50	0.62	0.95	3.07	0	0
168	Binuhangin	do.	20	8.82	1.40	0.54	0.95	2.89	0	0
169	Sinanduyong	do.	95	9.20	1.83	0.71	1.24	3.78	0	0
170	Malagitina puti	do.	85	8.99	2.10	0.83	1.28	4.21	0	0
171	Solo	Java.	90	8.76	1.54	0.58	0.74	2.86	0	0
172	Rogol	do.	95	7.99	2.10	0.65	1.09	3.84	0	0
173	Si rosaki	do.	90	8.72	1.65	0.68	1.13	3.46	0	0
174	Semas	do.	95	8.46	1.51	0.59	1.07	2.97	0	0
175	Djalen	do.	90	8.50	1.35	0.60	0.75	2.70	0	0
176	Songan	do.	90	8.17	1.26	0.55	0.87	2.68	0	0
177	Karang serang	do.	90	-----	1.26	0.68	1.07	3.01	0	0
178	Baok	do.	95	10.62	1.63	0.56	0.72	2.91	0	0
179	Merivimankotti	do.	90	10.62	1.59	0.64	0.88	3.11	0	0
180	Gedangan	do.	98	10.35	1.50	0.55	0.92	2.97	0	0

TABLE 1.—Chemical analyses of various rices and results of feeding same to pigeons—Continued.

No.	Name.	Locality.	Pericarp remaining.	Chemical analysis.						Result of feeding.		
				Mois- ture.	Fat.	Phos- phorus pentox- ide.	Ash.	Total.	Nitro- gen.	Amido- nitro- gen.	Beri- beri.	Beri- beri fac- tor.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	
181	Murmuray	Tarlac	85	10.85	2.02	0.69	0.96	3.67			0	0
182	Ubanan	do.	80	10.05	1.92	0.59	0.95	3.44			0	0
183	Ramai	do.	60	10.62	1.34	0.63	1.01	2.98			0	0
184	Bulake	Cotabato	45	10.82	1.05	0.58	0.87	2.50			75	0.37
185	Badyong	do.	20	10.86	0.97	0.56	0.80	2.33			0	0
186	Balasang	Ilocos Norte	65	8.67	1.47	0.53	0.86	2.86			0	0
187	Curapo	do.	80	8.00	1.59	0.69	1.16	3.44			0	0
188	Danacal	do.	88	8.57	1.41	0.59	1.08	3.08			0	0
189	Duanig	do.	70	8.51	1.66	0.66	1.03	3.35			0	0
190	Caraygay	do.	85	8.57	1.47	0.59	0.88	2.94			0	0
191	Malaka	do.	35	8.92	1.53	0.56	0.79	2.88			0	0
192	Maracatday	do.	70	8.63	1.28	0.56	0.95	2.79			0	0
193	Malaka	do.	60	8.19	1.64	0.51	0.80	2.95			0	0
194	Matanobong	do.	75	8.73	1.49	0.55	0.85	2.89			0	0
195	Matayesa	do.	80	8.55	1.67	0.60	0.92	3.19			0	0
196	Murmuray	do.	85	8.77	1.89	0.63	1.04	3.36			0	0
197	Santa Maria	do.	80	8.03	1.69	0.67	1.20	3.36			0	0
198	Glutinous rice No. 1.	Hongkong	0	9.94	0.34	0.27	0.49	1.10			100	4.00
199	Glutinous rice No. 2.	Shanghai	0	10.02	0.57	0.31	0.45	1.33			100	2.27
200	Glutinous rice No. 3.	Hongkong	0	9.63	0.59	0.25	0.48	1.32			100	3.03

arranged in sequence from the lowest to the highest and charted, together with the beriberi-producing factor for each rice (figs. 1 to 8).

II. DISCUSSION

1. *The beriberi factor.*—Our figures for the beriberi factor cannot be taken as an accurate quantitative index of the beriberi-producing potentialities of these rices, as is evidenced by the irregularities of the beriberi line in the charts. Nevertheless, the method of arriving at this factor is believed to be correct, and the inaccuracy is chiefly due to the fact that only a limited number of birds of various ages could be used in these experiments with the cage space and birds at our disposal. Had it been possible to feed twenty birds of the same age on each rice, this factor would have been more accurate, since the undoubted variation in individual susceptibility to polyneuritis would have exerted less influence on the result, and the beriberi line on the charts would have been much smoother.

Whatever the quantitative error, it is obviously the same for all of the chemical constituents of each rice used, and therefore this factor may be employed as a reliable guide to the determination of the most satisfactory chemical index of the beriberi-preventing rices. By viewing the charts it will appear that no matter whether ash, phosphorus pentoxide, or fat is used as indicator, the character of the curve is the same. At the lowest figures shown by the chemical analyses, the incidence of polyneuritis is high and, as the chemical figures rise, the line indicating the amount of polyneuritis drops. An irregular zone is thus reached for each chemical index where some rices produced polyneuritis and other rices afforded complete protection. Finally, with each index a figure is reached at which the beriberi factor drops to zero, and remains there for every rice having that particular quantity or more. Obviously that chemical index in which the irregular zone is reduced to a minimum will be the best.

2. *Amount of pericarp remaining on the grain as determined by staining and inspection.*—The staining-and-inspection method is quite exact for completely polished rices having none of the external layers remaining and for rices having these external layers practically intact. For rices having from 5 to 50 per cent of their external layers the method cannot be called exact, and is probably subject to at least a 10 per cent error. That is, it would probably be impossible to distinguish between rices

having in one case 45 per cent and in another case 50 per cent pericarp; but rices having 30 and 50 per cent, respectively, can be readily distinguished, and differences between 40 and 50 per cent are fairly noticeable.

It is also possible that all of the vitamin is not always contained exclusively in the external layers of the rice, and that most highly milled rices still contain traces of vitamin. This possibility is strongly suggested by the fact that pigeons fed on a synthetic diet of cornstarch 90 per cent, egg albumen 8 per cent, salt mixture 1 per cent, and cod-liver oil 1 per cent developed polyneuritis much faster than when fed on the most highly milled rices. Thus, in one such experiment, all four pigeons developed polyneuritis, in 12, 14, 18, and 18 days, respectively, giving a beriberi factor of 6.4, higher than the highest (4.0) obtained from the use of any rice in our series. McCarrison and Norris arrived at the same conclusion, since washing or autoclaving the most highly polished rices increased their capacity to produce polyneuritis. If traces of vitamin occur as a rule in such highly milled rices, certain exceptional samples may contain unusually large amounts, sufficient to prevent the development of beriberi.

Such unusual rices are undoubtedly the cause of some of the irregularities in our charts and may be responsible for the doubts that have arisen in the minds of some sanitary authorities concerning the validity of the theory that beriberi is caused by a deficiency arising from the consumption of highly milled rice.

Admitting these sources of error, the fact still remains that, in the examination of the two hundred rices of this series by this method, no rice having 50 per cent or more of the external layers of the grain produced polyneuritis when fed to pigeons (fig. 1). If this were taken as a standard it would have excluded seventeen rices that afforded complete protection, as follows: One rice out of fifteen having only 10 per cent; five rices out of seventeen having 20 per cent; two rices out of five having 25 per cent; three rices out of five having 30 per cent; two rices out of three having 35 per cent; three rices out of four having 40 per cent; and four rices out of five having 45 per cent. By consulting the charts it will be seen that this method of determining a rice that will prevent beriberi is more accurate than either ash, phosphorus pentoxide, or fat used as an index. This is a complete confirmation of previous ex-

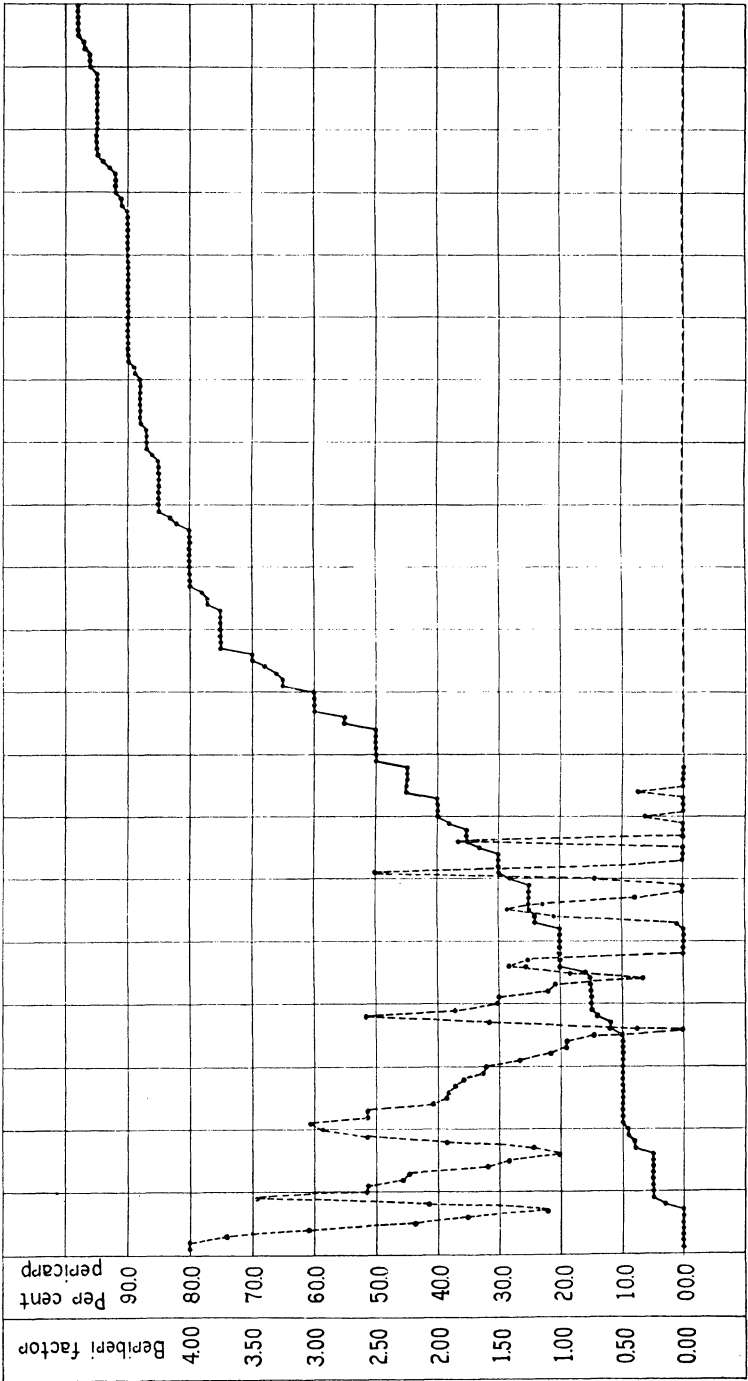


FIG. 1. Percentage of the external layers of the grain remaining on each rice (heavy line) and the beriberi factor for the same rices (broken line).

perience, indicating that this simple inspection of rice is the best method for selecting a rice that will afford protection.

Since pigeons are so much more susceptible to polyneuritis than the human race is to beriberi, it seems possible that any rice having 30 per cent of the external layers remaining on the grain will prevent human beriberi. The rarity of beriberi when hand-pounded rice is eaten is therefore readily explainable.⁴ Nevertheless, in purchasing rice for the Philippine Scouts, the endeavor has always been made to select a rice having the external layers nearly intact. Of the seven samples used in this series only one had as low as 88 per cent of the external layers, the remaining six samples ranging from 92 to 98 per cent.

This undoubtedly accounts for the uniform success in the prevention of beriberi in the Philippine Scouts since 1910, when such undermilled rice was furnished. This method is therefore to be recommended as the best and simplest for use in armies and institutions, where some experienced and responsible official can make the examination. Unfortunately, it cannot be recommended as a legal standard, because the administration of a law cannot depend entirely upon the judgment of any single individual, however skilled he may be.

According to the resolutions formulated by the sixth congress of the Far Eastern Association of Tropical Medicine, some terminology is desirable to designate these various degrees of milling. Accordingly, it is suggested that rices in the process of milling may be stained with iodine and inspected, and that those rices having from 0 to 20 per cent of the external layers be called "highly milled rice;" from 21 to 49 per cent, "medium-milled rice;" and from 50 to 100 per cent, "undermilled rice." These names, besides being convenient, would correspond to the facts with regard to the incidence of beriberi. Beriberi may be expected to be prevalent when highly milled rice is used as a dietary staple. When medium-milled rice is so used, cases of beriberi may not occur at all, or may sometimes occur, but the cases will be more apt to be sporadic. When undermilled rice is used, beriberi will not occur at all.

3. *Amido-nitrogen as an index.*—The determination for amido-nitrogen appeared to bear no relation to the beriberi-producing

⁴ Of course, beriberi may occur when hand-pounded rice is used, provided the pounding is carried to the point where a highly milled rice is produced. Of the 152 samples procured through the Bureau of Agriculture, which were all hand-pounded, 37 produced polyneuritis in pigeons.

potentialities of the rices. Some of the rices having the highest amounts of amido-nitrogen produced polyneuritis, while a number of samples having no amido-nitrogen afforded complete protection. This chemical estimation was discontinued after fifty samples were tested, of which thirty-five were in this series. The actual figures, with the results of feeding, are included in Table 1.

4. *Ash as an index*.—No polyneuritis occurred on any rice having at least 1.05 per cent of ash. However, if this were taken as a standard, it would have excluded not only all the rices that produced polyneuritis, but also fifty-eight rices that afforded complete protection. The zone of irregularity covered ninety-six rices, or almost half of the entire number (see fig. 2).

5. *Phosphorus pentoxide as an index*.—No polyneuritis occurred on any rice having at least 0.62 per cent phosphorus pentoxide. This standard would have excluded forty-five rices that afforded complete protection. The irregular zone was also very wide, including eighty-six rices (see fig. 3). It will thus be seen that the phosphorus pentoxide standard is better than the ash, but is not nearly so good as the fat standard. It was evident that certain highly milled and beriberi-producing rices might contain a very high percentage of phosphorus; forty-three samples that produced polyneuritis contained 0.4 per cent or more phosphorus pentoxide; twenty-seven samples contained 0.5 per cent or more phosphorus pentoxide; and two samples contained, respectively, 0.60 and 0.61 per cent. Allowance must be made for the fact that pigeons, known to be highly susceptible birds, were used. It is probable that some of these rices would have protected fowls, and still more probable that they would not have caused beriberi in man. Nevertheless, none of them contained 50 per cent of the external layers of the grain, and three of these rices, Nos. 26, 43, and 92, containing, respectively, 0.43, 0.49, and 0.47 phosphorus pentoxide, were the so-called "choice rice" sold by the Quartermaster, which anyone could identify at a glance as highly milled rice that would produce beriberi. It is obvious that the old standard of 0.4 per cent is too low, and that an acceptable standard must lie between 0.5 and 0.62, preferably at the higher point, since we can at least assume that no rice that protects pigeons would cause beriberi in man.

6. *Fat as an index*.—No polyneuritis occurred with any rice having at least 1.28 per cent of fat or more. If taken as standard, this would have excluded twenty-five rices that afforded com-

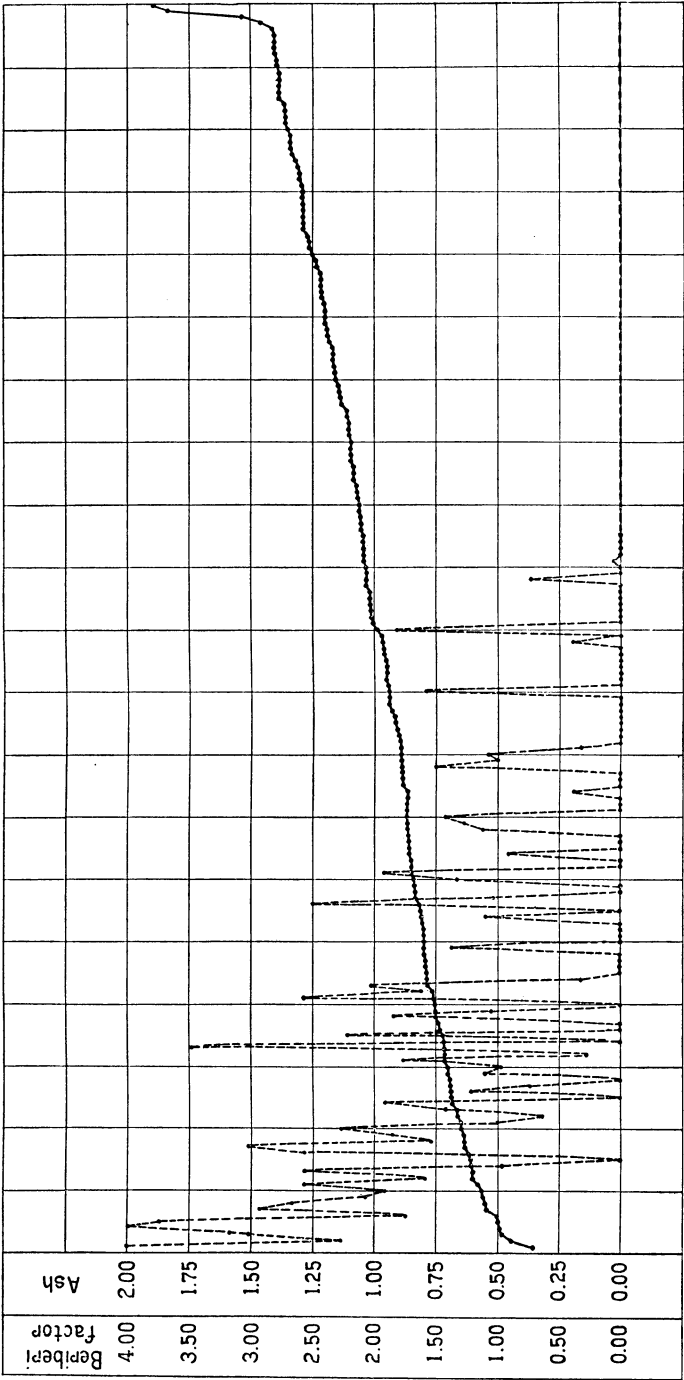


FIG. 2. The percentage of ash and the beriberi factor for each rice.

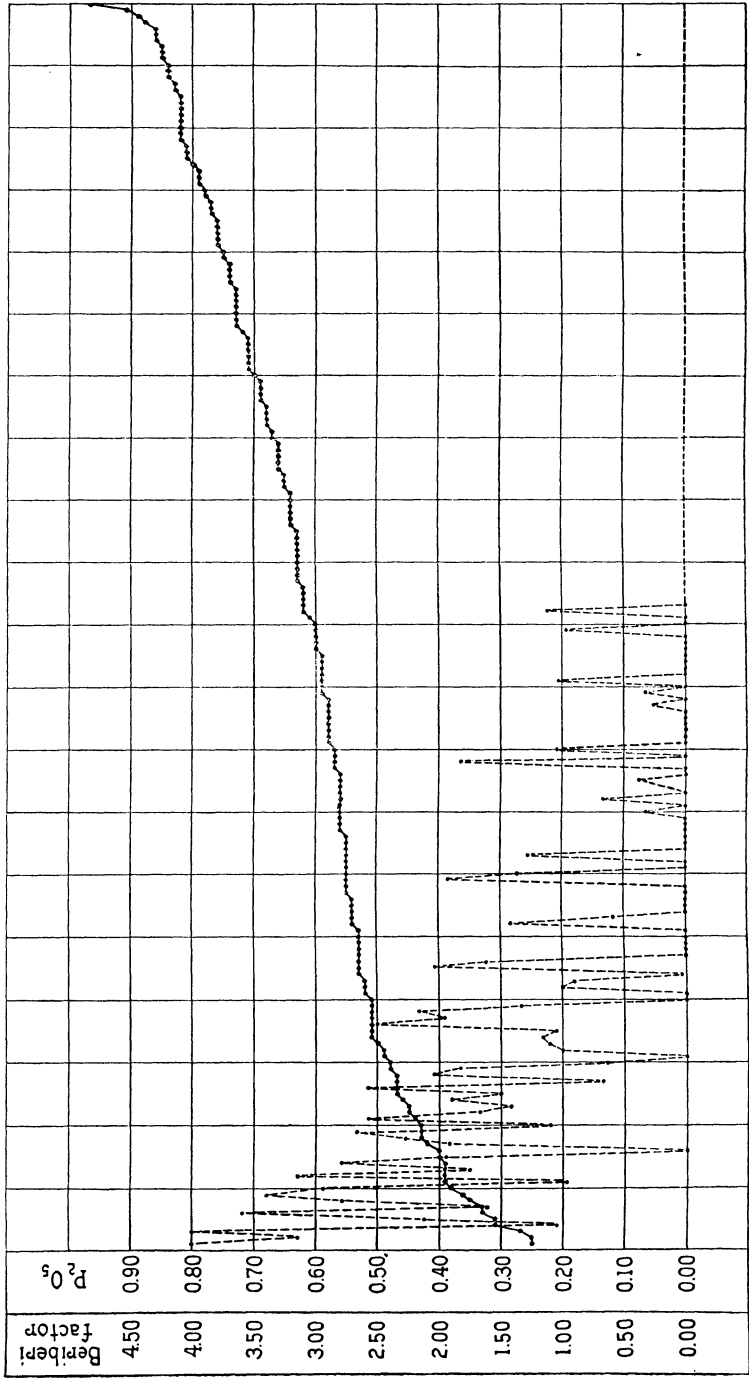


FIG. 3. The percentage of phosphorus pentoxide (P₂O₅) and the beriberi factor for each rice.

plete protection. The zone of irregularity included fifty-four rices (fig. 4). It is clear therefore that the percentage of fat would constitute a better index for a beriberi-preventing rice than the ash or the phosphorus pentoxide.

A satisfactory standard should exclude all rices that produce beriberi and should exclude none, or at least very few, that afford complete protection. Neither the ash, the phosphorus pentoxide, nor the fat fulfills these requirements. There remains the possibility that some combination of these three chemical determinations would be better than either one alone; for, when a highly milled rice contains an unusually high percentage of phosphorus, it is possible that either the mineral salts or the fat may be low, and thus the irregularities of any single determination would be corrected.

7. *Phosphorus pentoxide plus ash*.—The percentage of phosphorus pentoxide and ash were added and the total so obtained charted as before. No rice containing a total of 1.70 or more phosphorus pentoxide plus ash produced polyneuritis. This standard would have excluded forty-three rices that protected, and the zone of irregularity included eighty-four rices (fig. 5). This combination is evidently very little better than phosphorus pentoxide alone.

8. *Phosphorus pentoxide plus fat*.—When these were totalled and charted, it was found that no rice having 1.77 per cent or more of combined phosphorus pentoxide and fat produced polyneuritis in pigeons. This standard would have excluded only fourteen rices that afforded protection, and the zone of irregularity included forty rices (fig. 6). This is a distinct improvement on the fat alone, and it is evident that some of the irregularities have been corrected by the use of this combined standard.

9. *Phosphorus pentoxide plus fat plus ash*.—The percentages of these three ingredients were added and the totals charted. No rice having a total of 2.70 or more produced any polyneuritis when fed to pigeons. If this were used as a standard, only thirteen rices that afforded complete protection would be excluded. The zone of irregularity included only thirty-nine rices (fig. 7).

10. *Two fat plus phosphorus pentoxide*.—Since the fat evidently formed the best single standard, the possibility was considered that more irregularities might be corrected if the fat were given a greater weight. For this purpose, the per-

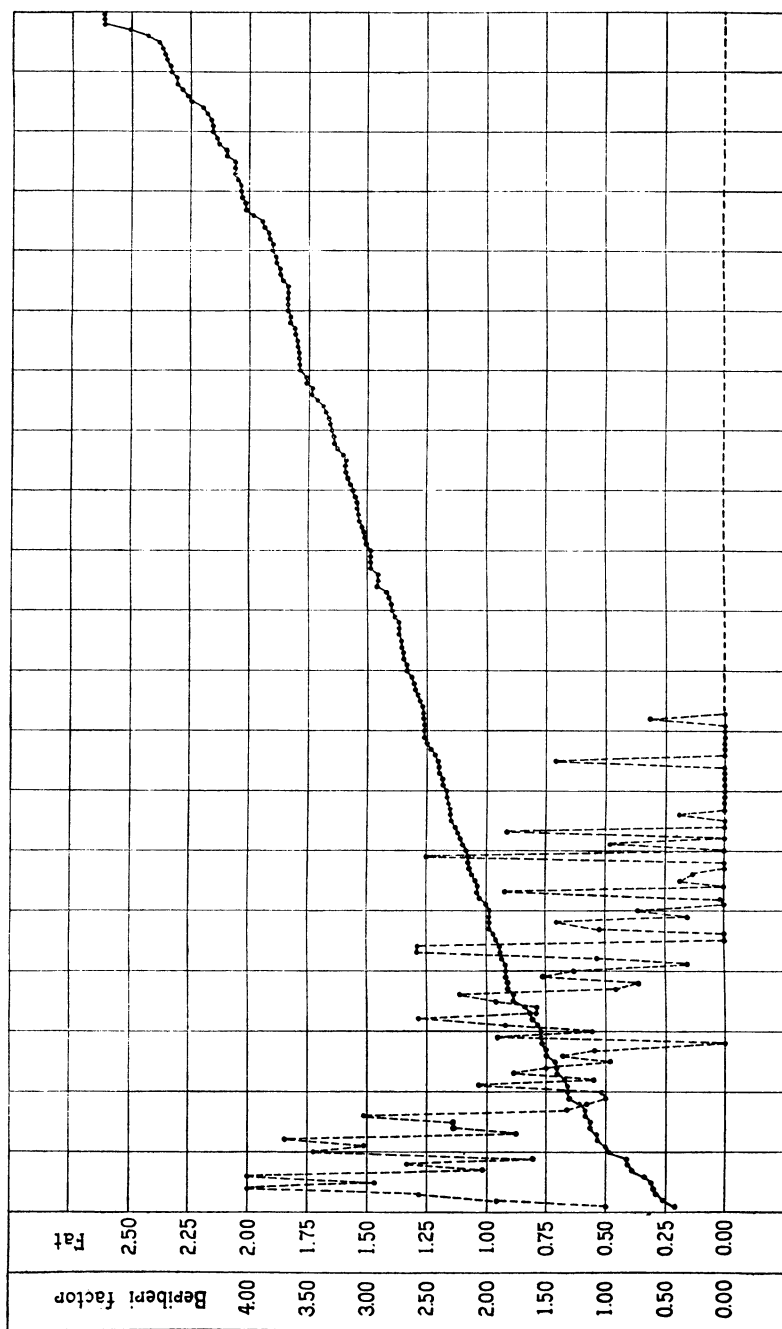


FIG. 4. The percentage of fat and the beriberi factor for each rice.

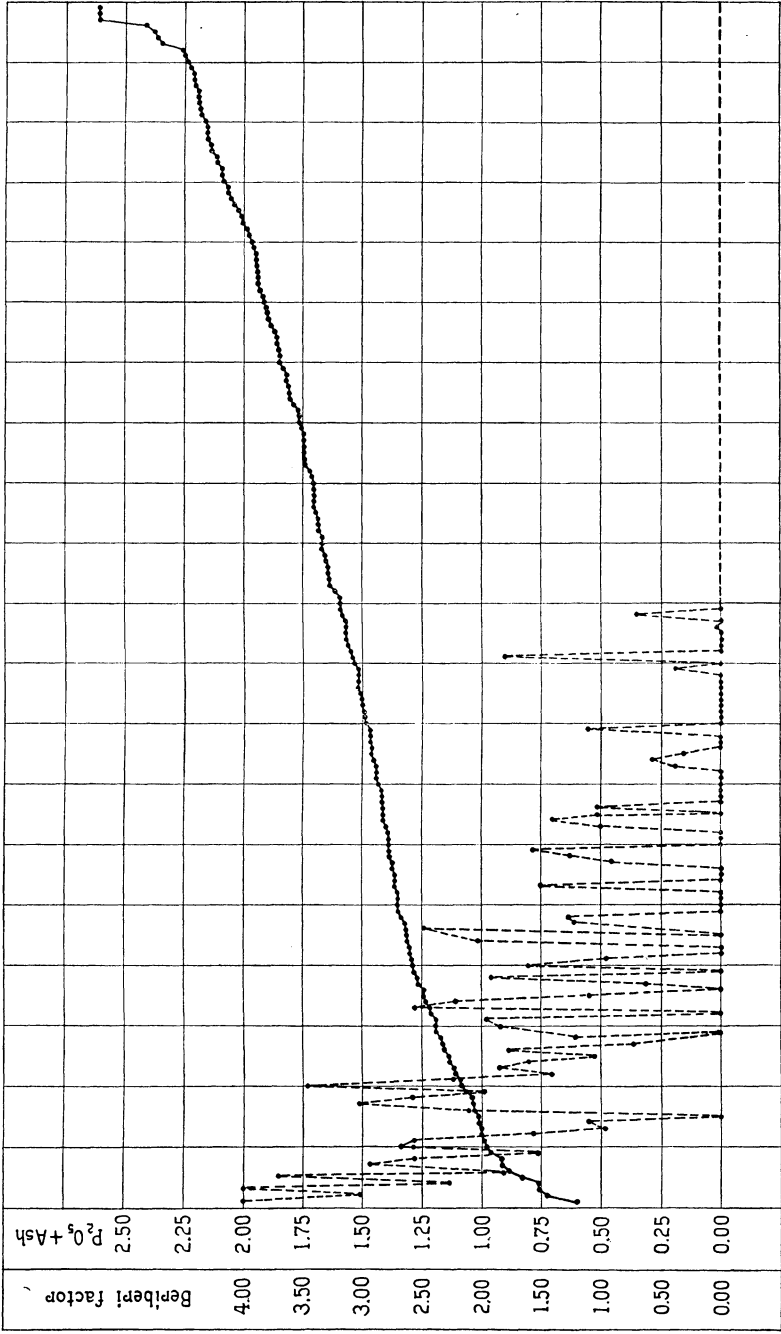


FIG. 5. The combined percentages of phosphorus pentoxide (P_2O_5) and ash in relation to the beriberi factor.

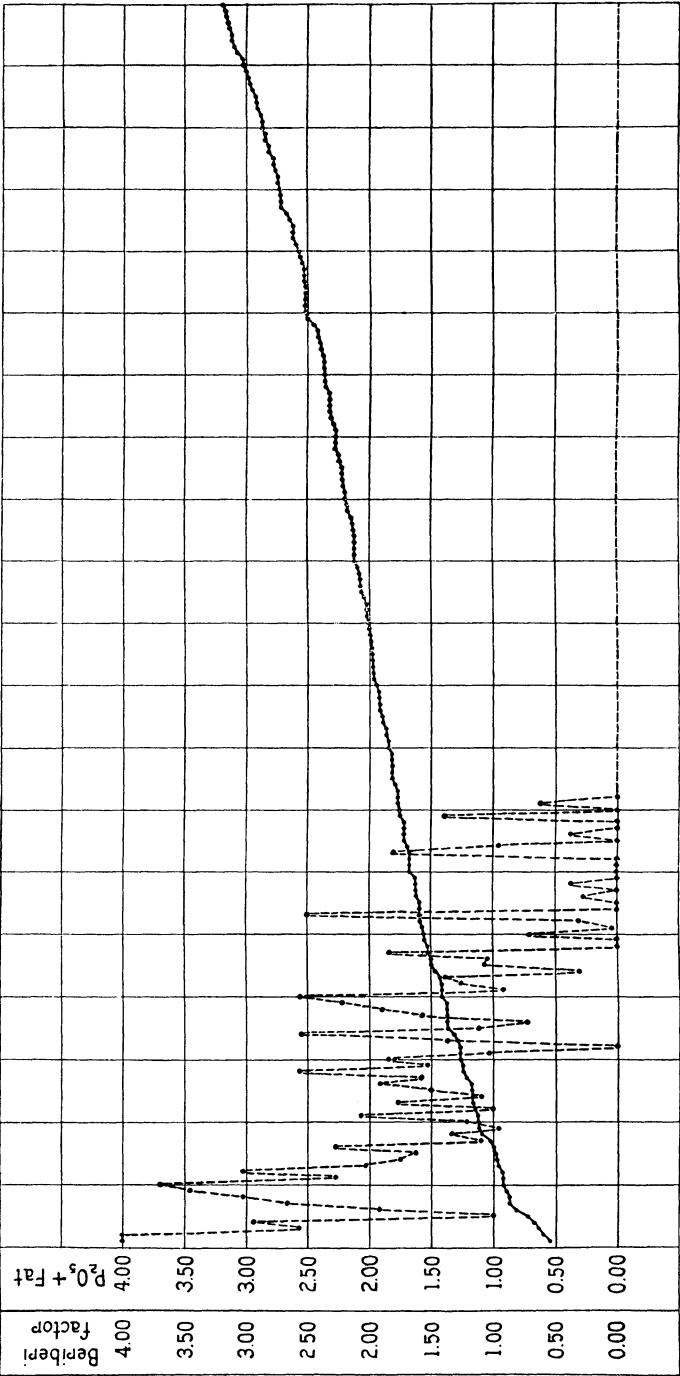


FIG. 6. The combined percentages of phosphorus pentoxide (P₂O₅) and fat and the beriberi factor for each rice.

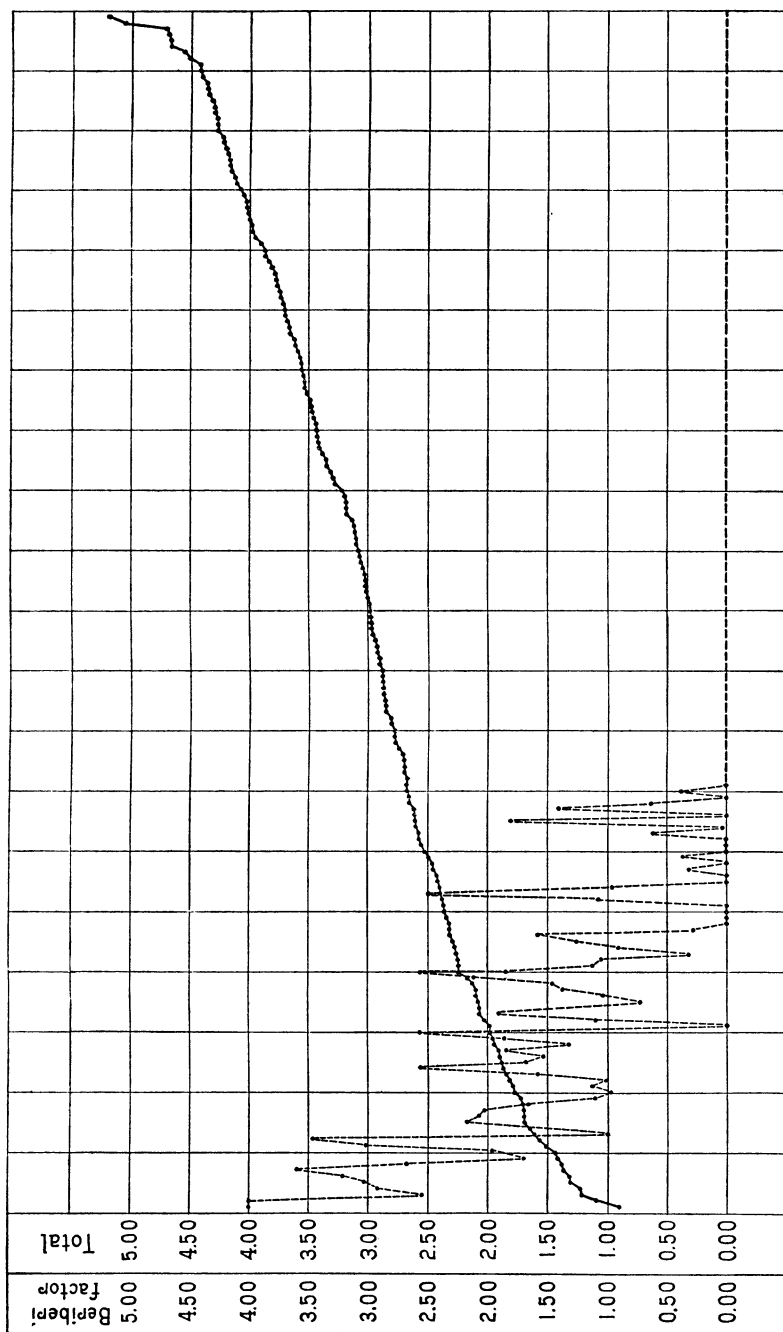


Fig. 7. The combined percentages of phosphorus pentoxide (P_2O_5) and total ash and the beriberi factor for each rice.

centage of fat was doubled and added to the percentage of phosphorus pentoxide. No rice containing a total of 3.07 or more, so figured, produced polyneuritis. This standard would have excluded seventeen rices that protected, and the zone of irregularity included forty-three rices (fig. 8). This standard was evidently somewhat less accurate than the simple addition of the percentages of fat and phosphorus pentoxide.

11. *Two fat plus 1 phosphorus pentoxide plus 1 ash.*—The percentage of fat was doubled and added to the percentage of phosphorus pentoxide and ash. No rice having a total of 3.94 or more, so computed, produced polyneuritis. If this were used as a standard, thirteen rices that afforded protection would be excluded, and the zone of irregularity included forty-four rices. A standard derived by such a computation is obviously not so good as the simple total of phosphorus pentoxide, fat, and ash, which is the best standard.

The selection of the most suitable index.—While the total of phosphorus pentoxide, fat, and ash placed at 2.70 was unquestionably the best chemical index for this series of two hundred rices (excluding thirteen rices that protected), it was only slightly better than the sum of the phosphorus pentoxide and fat when placed at 1.77 (excluding fourteen rices that protected). Simplicity is also worthy of consideration, since the more complex the chemical procedure, the greater the possibility of technical error and the more time-consuming the determination of the index of a given rice. Moreover, the ash is the poorest single index, and varies more than any other constituent, since it depends chiefly upon the amount of mineral salts in the soil. For these reasons the standard of 1.77 phosphorus pentoxide plus fat would seem the more desirable.

Of the one hundred twenty-nine rices containing this amount or more of phosphorus pentoxide plus fat that afforded complete protection to pigeons, only one (No. 34) contained as little as 0.4 per cent phosphorus pentoxide. This standard may therefore be improved by adding the proviso that the amount of phosphorus pentoxide must be at least 0.4 per cent.

Using the percentage of phosphorus pentoxide alone as a standard, all rices having at least 0.62 phosphorus pentoxide afforded protection. Of the fourteen rices that afforded complete protection having less than 1.77 phosphorus pentoxide plus fat three, Nos. 157, 149, and 54, had, respectively, 0.62, 0.63, and 0.64 phosphorus pentoxide. The standard of phosphorus

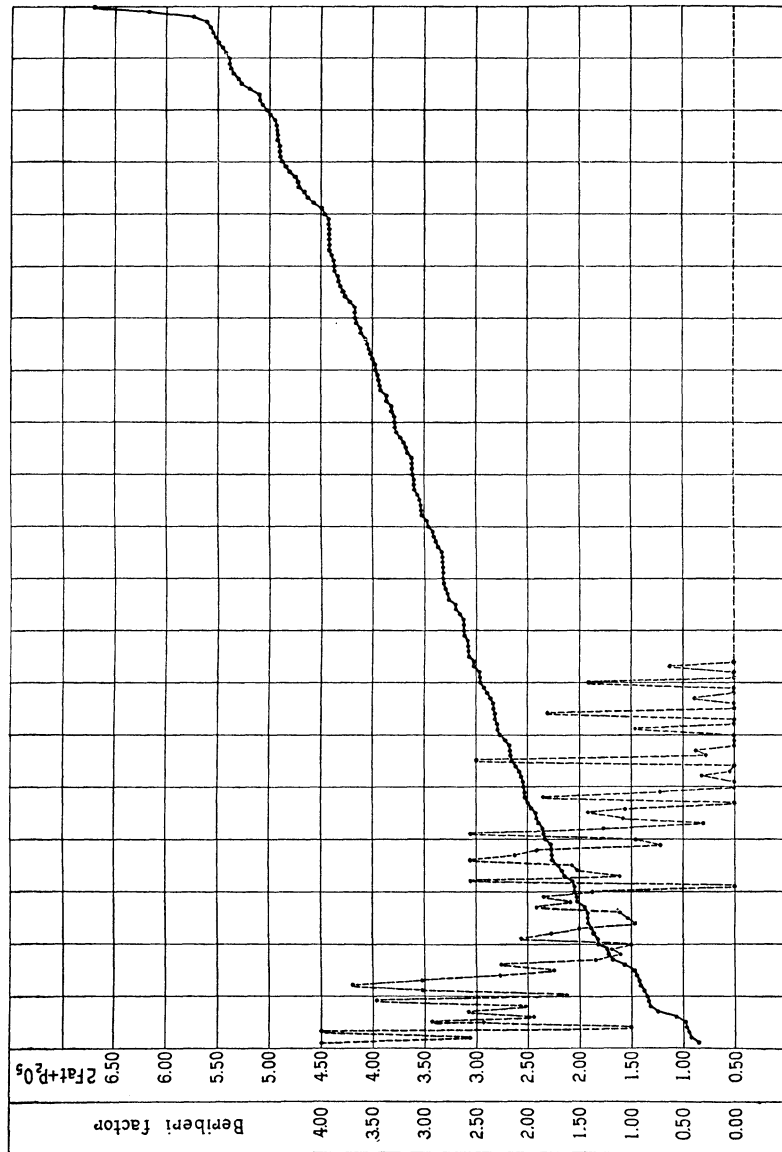


Fig. 8. The percentages when the percentage of fat was doubled and added to the percentage of phosphorus pentoxide (P_2O_5) compared with the beriberi factor.

pentoxide plus fat may be further improved by a proviso including any sample of rice having at least 0.62 phosphorus pentoxide.

Three of the rices having less than 1.77 phosphorus pentoxide that protected pigeons had at least 75 per cent of the external layers of the grain and no less than 0.5 per cent phosphorus pentoxide (No. 54, 75 per cent; No. 35, 77 per cent; and No. 22, 85 per cent). The chemical standard might be improved by including any rice having at least 0.5 per cent phosphorus pentoxide and not less than 75 per cent pericarp.

The tentative standard for beriberi-preventing rice would therefore read as follows: *Any rice having 1.77 per cent of phosphorus pentoxide plus fat, but not less than 0.4 per cent phosphorus pentoxide; or any rice having not less than 0.62 phosphorus pentoxide; or any rice having not less than 0.50 per cent phosphorus pentoxide and with at least 75 per cent of the external layers of the grain remaining.*

This standard may be considered as absolutely safe for man, in view of the fact that such rices afforded complete protection to pigeons when used as an exclusive diet. Moreover, this standard excluded only nine rices that afforded protection out of a total of two hundred, or 4.5 per cent, and the examination required would be little more difficult and no more time-consuming than the estimation of phosphorus pentoxide alone. It is believed that this is the best chemical standard that can be devised in the absence of any direct method of estimating the exact amount of antineuritic vitamin, and it is accordingly submitted as a basis for discussion.

III. THE EFFECT OF DEFECTS IN THE STORAGE OF RICE AND IN ITS PREPARATION FOR FOOD ON THE PROPOSED STANDARD

The determination of a standard for beriberi-preventing rice is but the first part of the solution of the administrative problem. The prevention of beriberi in native populations depends not only upon the provision of an adequate beriberi-preventing rice, but almost equally upon the provision of facilities for the proper storage of such rice and upon correct methods of its preparation for food.

In order to determine the effect of washing rice, ten samples of rice were analyzed for their phosphorus pentoxide content, washed, and analyzed again after washing. The method of washing was as follows: The rice was placed in a saucepan and

washed with running water until the water came away clear, which usually required about five minutes. The rice was then dried with an electric fan until all excess water was evaporated. The rice was not handled or stirred during the washing. The results of this experiment are shown in Table 2, and it will be seen that in every case the phosphorus pentoxide content was greatly reduced. Calculated on a dry basis, all ten samples originally contained at least 0.4 per cent phosphorus pentoxide, while after washing no sample contained 0.4 per cent, the average loss for the ten samples being 0.25 per cent phosphorus pentoxide. Presumably the vitamin content of these rices was similarly reduced. When excess water is used in cooking and this is strained off, a further loss of phosphorus pentoxide and of vitamin occurs.

TABLE 2.—Comparative phosphorus pentoxide content of washed and unwashed rice.

Sample identification No.	Before washing.			After washing.			Phosphorus pentoxide content.
	Moisture.	Calculated from sample as received.	Calculated from dry basis (a).	Moisture.	Washed samples, air dried.	Calculated from dry basis (b).	Difference between (a) and (b).
	<i>P. ct.</i>	<i>P₂O₅ p. ct.</i>	<i>P₂O₅ p. ct.</i>	<i>P. ct.</i>	<i>P₂O₅ p. ct.</i>	<i>P₂O₅ p. ct.</i>	<i>P. ct.</i>
1.....	11.15	0.369	0.415	9.41	0.160	0.177	0.238
2.....	11.00	0.402	0.451	8.73	0.187	0.204	0.247
3.....	11.08	0.371	0.417	9.73	0.181	0.201	0.216
4.....	11.56	0.426	0.482	8.23	0.191	0.208	0.274
5.....	10.97	0.358	0.402	10.01	0.172	0.191	0.211
6.....	12.07	0.402	0.457	8.33	0.171	0.187	0.270
7.....	11.59	0.420	0.475	9.24	0.174	0.192	0.282
8.....	11.46	0.396	0.447	9.92	0.157	0.174	0.273
9.....	11.91	0.414	0.470	8.07	0.172	0.187	0.283
10.....	11.54	0.408	0.461	9.81	0.230	0.255	0.206

Previous writers, including Schüffner and Kuenen and McCarrison and Norris, have shown that prolonged washing or soaking of the rice, prior to cooking, extracts and removes a considerable portion of its vitamin, and that an originally beriberi-preventing rice may be thus converted into a beriberi-producing rice. This is what would be expected, in view of the fact that the antiberiberi vitamin is very freely soluble in water, and there would be no necessity for emphasizing this point except for the fact that ignorance of this possibility has frequently caused confusion of ideas concerning the etiology of beriberi and has

thrown suspicion upon the validity of a standard for beriberi-preventing rice.

At the 1912 meeting of the Far Eastern Association of Tropical Medicine at Hongkong⁽³⁾ an instance was related of two neighboring institutions, a monastery and a convent, that had been supplied with the same rice. There was no beriberi in the monastery, but the disease was prevalent in the convent. We were later informed by Dr. Victor G. Heiser that on investigation it was found that the monks were not very particular about washing their rice, but that the nuns, with true feminine insistence upon cleanliness, washed their rice very thoroughly, and that this simple procedure was the explanation of the peculiar incidence of beriberi among the nuns.

Again, the idea has been advocated that beriberi is a place disease, depending upon some other factor than a deficient food for its production. Thus it has been found that beriberi is, and has been for many years, endemic in certain narrow tracts in India, and that the disease occurs in these endemic areas even though hand-pounded, undermilled, or parboiled rice is used.

It is by no means necessary to assume that beriberi is a place disease, or that its etiology is any different in India than in the Philippines or other countries, in order to explain such facts. Not knowing the food habits in India, we do not presume to say what they are; but it can hardly be wrong to assume that the people in such endemic regions of India are like people everywhere else in being firmly addicted to some particular diet, cooked in some special manner. It follows that, if there be any deficiency or abnormality in the diet or the method of cooking, this tendency is fixed and handed down from generation to generation, and that this alone will account for the fact that beriberi is endemic in certain localities. It seems probable that excessive washing of rice, boiling in an excessive quantity of water, or some other peculiarity in its preparation, is sufficient to account for the incidence of beriberi in these endemic areas among people using undermilled or parboiled rice.

Such erroneous food habits cannot be changed by sanitary regulations and can be changed but slowly as the result of education, and therefore they constitute one of the most serious difficulties in the eradication of beriberi in all countries. It is to obviate such difficulties as much as possible that we have recommended such a high standard for a beriberi-preventing rice. A lower standard would undoubtedly suffice if it were

not for such factors as excessive washing, pressure cooking, and other procedures that cannot be foreseen; but the standard recommended at least provides a considerable margin of safety.

At least the storage of rice is subject to sanitary regulation and deserves investigation. Long storage alone is insufficient to account for the transformation of a beriberi-preventing rice into a beriberi-producing rice. In previous papers(4, 5) it was shown that fermented undermilled rice might still be capable of preventing polyneuritis in fowls, and that undermilled rice might be kept for one year in a damp place and that, although then musty and unfit for human consumption, it still prevented the development of polyneuritis in fowls when fed as an exclusive diet. On the other hand, numerous apparently well-authenticated instances have been related in which more or less prolonged storage of undermilled rice resulted in the production of beriberi. An explanation of this discrepancy is desirable.

During the course of the experimental work on the determination of a standard for beriberi-preventing rice, it was early noted that some samples of rice were heavily infested with insects. Twenty of such heavily infested samples were selected for a special series, analyzed, and kept in cans as described previously, except that no chloroform was added to kill the insects which were permitted to live in the rice. These rices were fed to pigeons, and at the end of one hundred days, when the experiment was discontinued, the remainder of the rice was again analyzed. Samples of these rices were submitted to Mr. W. Schultze, formerly entomologist of the Bureau of Science, for identification of the insects, which he found to be—

Rice weevil, *Sitophilus oryzae* Linn.

Rice moth, *Corcyra cephalonica* Staint.

Rust-red flour beetle, *Tribolium ferrugineum* Fabr.

Granary weevil, *Sitophilus granarius* Linn.

The results of this experiment, showing the analysis of the rice before feeding and at the conclusion of the experiment, as well as the percentage of beriberi produced in pigeons and the beriberi factor are given in Table 3. It will be seen that seven rices, Nos. 1, 2, 9, 11, 15, 17, and 18, each contained originally more than 1.77 per cent phosphorus pentoxide plus fat which, in accordance with our other work, should have prevented polyneuritis; nevertheless, polyneuritis occurred with every rice used in this series. The analysis of the rice remaining at the end of one hundred days showed that in no case was the content

of phosphorus pentoxide plus fat as high as it was at first, nor was it in any case as high as 1.77 per cent, the highest total being 1.67 (No. 18); nor is the result changed if we take the total of phosphorus pentoxide, fat, and ash. Again, seven rices contained originally more than 2.70, whereas at the conclusion of the experiment the highest total was 2.34 (No. 1).

As the result of the depredations of insects, an average total of 2.61 was reduced to 1.71, or an average loss for each sample of rice of 0.89 per cent phosphorus pentoxide plus fat plus ash. Nor does this indicate the full extent of the damage, for the insects eat the outer layers of the grain most readily, so that those rices having the greatest proportion of the external layers as a rule suffered the greatest loss. Thus, sample No. 1 lost 1.45 per cent; No. 2, 1.78; No. 9, 1.80; No. 10, 1.24; No. 11, 1.85; No. 15, 0.90; No. 17, 0.86; No. 18, 0.75.

From the figures it is clear that a beriberi-preventing rice kept in storage, under such circumstances as to be subject to the depredations of insects, may frequently be converted into a beriberi-producing rice; for, as the insects eat away the external layers of the grain, an undermilled rice is in fact converted into a highly milled rice. The external layers, being the richest food supply, are evidently preferred by insects, and this accounts for the difficulty in storing undermilled rice. I was informed by the Quartermaster that choice rice (highly milled) could be stored a maximum of six months, while the undermilled rice intended for the Philippine Scouts could never be stored more than three months. The tendency for undermilled rice to become infested with insects is the main reason for the reluctance of rice wholesalers to handle such rice, and some practical method of meeting this difficulty must be forthcoming if the use of undermilled rice is to be enforced.

In some countries where milling facilities are ample, rice should be milled only as it is required for consumption, and undermilled rice should not be stored by the wholesaler for longer than a few weeks. Such a regulation will be more difficult to apply in other countries like the Philippines where the rice mills have a small capacity and, accordingly, the rice milled from day to day must be stored until a sufficient amount accumulates to make a shipment. In any case, however, long storage of rice is more a matter of convenience to the dealer than a necessity. The United States Army Quartermaster has found no difficulty in securing special orders of undermilled rice for

TABLE 3.—Analyses of rices, before and at conclusion of the feeding experiments.

No.	Name.	Locality.	Analysis before feeding.				Analysis after feeding.				Beriberi factor.			
			Mois- ture.	Fat.	Phospho- rus pen- toxide.	Ash.	Total.	Mois- ture.	Fat.	Phospho- rus pen- toxide.		Ash.	Total.	
1	Scout rice.....	Pangasinan.....	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	1.32
2	Apostol.....	Rizal.....	10.07	1.73	0.87	1.19	3.79	11.20	1.07	0.49	0.78	2.34	75	0.64
3	Inadhica.....	do.....	10.05	1.36	0.51	0.95	2.82	10.75	0.18	0.35	0.51	1.04	50	0.96
4	Roxas.....	do.....	10.16	1.10	0.44	0.81	2.35	11.49	0.64	0.45	0.74	1.83	75	0.56
5	Quinalibo.....	do.....	9.62	1.17	0.52	0.80	2.49	11.56	0.29	0.30	0.40	0.99	50	2.43
6	Cruz.....	do.....	10.33	1.27	0.44	0.71	2.42	11.43	0.92	0.37	0.63	1.92	100	2.63
7	Magsalit.....	do.....	9.79	1.02	0.48	0.75	2.25	11.57	0.64	0.43	0.67	1.74	100	1.53
8	Connor.....	do.....	9.93	1.06	0.46	0.81	2.33	11.91	0.68	0.38	0.71	1.77	50	1.38
9	Binarbang.....	Laguna.....	10.06	1.00	0.50	0.90	2.40	11.28	0.66	0.47	0.83	1.96	25	0.52
10	Binuhangin.....	do.....	10.28	1.32	0.61	1.01	2.94	11.25	0.70	0.49	0.67	1.86	50	0.63
11	Guinanggang.....	do.....	10.48	1.01	0.60	1.46	3.07	10.74	0.53	0.53	0.77	1.83	75	0.92
12	Minantica.....	Nueva Ecija.....	10.78	1.66	0.63	1.13	3.42	11.00	0.53	0.44	0.60	1.57	100	1.61
13	Macan cumpul.....	do.....	10.91	1.06	0.52	0.58	2.26	10.99	0.48	0.34	0.52	1.24	75	1.19
14	Macan Polo.....	do.....	10.58	1.00	0.56	0.76	2.32	10.97	0.53	0.40	0.53	1.46	50	0.53
15	Binulagsac.....	do.....	10.11	1.11	0.42	0.54	2.07	10.87	0.70	0.32	0.48	1.50	75	1.41
16	Macan aga.....	do.....	10.09	1.35	0.44	0.72	2.51	10.68	0.75	0.36	0.50	1.61	50	0.93
17	Sampaguita.....	do.....	10.55	1.18	0.48	0.51	2.17	10.83	0.89	0.29	0.59	1.77	50	0.64
18	Macan ning.....	do.....	10.58	1.32	0.68	0.87	2.87	10.84	0.72	0.49	0.80	2.01	75	0.92
19	Macanining.....	Pangasinan.....	9.82	1.53	0.72	1.04	3.29	10.82	1.17	0.50	0.87	2.54	25	0.38
20	Caviteña.....	Nueva Ecija.....	12.40	1.03	0.60	0.87	2.50	10.90	0.62	0.49	0.81	1.92	100	2.56

the Philippine Scouts at frequent intervals, thus avoiding long storage. If undermilled rice were produced by law, dealers should be prevented by a suitable ordinance from keeping it in storage for long periods of time.

Infestation by insects may be also reduced by the enforcement of sanitary regulations in rice mills. Insects breed freely in accumulations of rice polish about such mills. An ordinance to regulate rice mills in the Philippines provides that, in every rice mill where labor is employed, all refuse, waste, and sweepings shall be removed at least once a day, and that an insanitary condition shall be deemed to exist if the rice in the process of milling, packing, storing, or transporting is not securely protected from mold and the development of weevils and beetles which destroy the mealy layer, and if the refuse, dirt, and waste products incident to the milling, storing, or transporting of rice are not removed daily; but this excellent regulation is nowhere strictly enforced.

So far as undermilled rice is concerned, even the strict enforcement of this regulation would not entirely prevent the subsequent development of insects in the sacked rice, because the grains themselves frequently carry the eggs that have been deposited upon them in the field before the rice is brought to the mill. Ottow⁽⁶⁾ in 1915 recommended the use of carbon tetrachloride as a preservative for undermilled rice, stating that there was no objection to the use of this substance even on a large scale. For this purpose a wide-mouthed bottle or tin containing the preservative absorbed by cotton was introduced into each sack of rice. This killed the insects, had no influence on the taste or smell of the cooked rice, and it is noninflammable. So far as we are aware, this simple method has never been given a thorough trial in any other country; it is at least worthy of further consideration.

Another method that has been recommended and widely used in the United States,⁽⁷⁾ for controlling mill insects in flour mills and grain elevators, is the use of heat. It has been found that a temperature of from 118 to 125° F., maintained for several hours to enable the heat to penetrate all the infested parts, will effectively kill all insects and insect eggs, and does not injure the grain in any way. The heat is obtained from steam pipes, and regulated by thermometers in various parts of the building. Such heat is more readily applied in the Tropics than in the United States.

One of the largest rice dealers in Manila has agreed to give this method a trial, and is fitting up a small room that can be tightly closed and heated, in which five hundred sacks can be treated at one time. If this experiment is successful, a further report will be made.

SUMMARY AND CONCLUSIONS

1. The proportion of the external layers remaining on a given rice may be determined with reasonable accuracy by simple inspection after staining with Gram's iodine solution.

2. When the rices of this series were examined in this manner, it was found that no rice having 50 per cent or more of the external layers of the grain produced polyneuritis when fed to pigeons.

3. Human beriberi can also be prevented by selecting rice in this manner, which is recommended as the best and simplest method for use in armies and institutions. It cannot be recommended as a legal standard.

4. This method may also be used during the milling process to determine the degree of milling, since it requires only several minutes to apply it.

5. It is suggested that rices in the process of milling or as sold be classified as follows:

- a. *Highly milled rice.* Having from 0 to 20 per cent of the external layers.
- b. *Medium-milled rice.* Having from 31 to 49 per cent of the external layers.
- c. *Undermilled rice.* Having from 50 to 100 per cent of the external layers.

6. The results obtained in this study indicate that amido-nitrogen is useless as a chemical index; 1.05 per cent ash is a poor index; 0.62 per cent phosphorus pentoxide is somewhat better; and 1.28 per cent fat is the best single chemical index for a beriberi-preventing rice.

7. The chemical index proposed for beriberi-preventing rice is: *Any rice having 1.77 per cent of phosphorus pentoxide plus fat, but not less than 0.4 per cent phosphorus pentoxide; or any rice having not less than 0.62 per cent phosphorus pentoxide; or any rice having not less than 0.50 per cent phosphorus pentoxide and with at least 75 per cent of the external layers of the grain remaining.*

8. No rice of this series possessing these requirements produced polyneuritis in pigeons, and this standard excluded only nine rices out of two hundred that afforded protection to pigeons.

9. Since pigeons are so much more susceptible to the deficiency of antineuritic vitamin than is man, and since man seldom lives on rice alone, a standard that will protect pigeons will not only protect man, but also will provide a factor of safety.

10. This factor of safety is necessary if beriberi is to be eradicated, because defects in the storage of rice or in its preparation for food may materially reduce its vitamin content.

11. Of ten rice samples tested, thorough washing reduced the phosphorus pentoxide content from an average of 0.447 to an average of 0.197 per cent. Presumably the vitamin content was similarly reduced.

12. In an experiment with twenty insect-infested rices stored for one hundred days, an average total of 2.61 per cent (fat, phosphorus pentoxide, and ash) was reduced to 1.71, and seven undermilled rices that should have prevented polyneuritis were converted into highly milled rices that produced polyneuritis.

13. It therefore appears probable that the loss of vitamin during long storage of undermilled rice is caused by the depredations of insects that eat the external layers of the grain.

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ILLUSTRATIONS

PLATE 1

- FIG. 1. Polyneuritis in one of the pigeons in this series of feeding experiments.
2. The pigeon shown in fig. 1, photographed twenty-four hours later, cured by one feeding of tikitiki.

PLATE 2

Shed and cages in which pigeons were kept during the feeding experiments.

TEXT FIGURES

- FIG. 1. Chart showing percentage of the external layers of the grain remaining on each rice (heavy line) and the beriberi factor for the same rices (broken line).
2. Chart showing the percentage of ash and the beriberi factor for each rice.
 3. Chart showing the percentage of phosphorus pentoxide (P_2O_5) and the beriberi factor for each rice.
 4. Chart showing the percentage of fat and the beriberi factor for each rice.
 5. Chart showing the combined percentages of phosphorus pentoxide (P_2O_5) and ash in relation to the beriberi factor.
 6. Chart showing the combined percentages of phosphorus pentoxide (P_2O_5) and fat and the beriberi factor for each rice.
 7. Chart showing the combined percentages of phosphorus pentoxide (P_2O_5) and total ash and the beriberi factor for each rice.
 8. Chart showing the percentages when the percentage of fat was doubled and added to the percentage of phosphorus pentoxide (P_2O_5) compared with the beriberi factor.



1



2

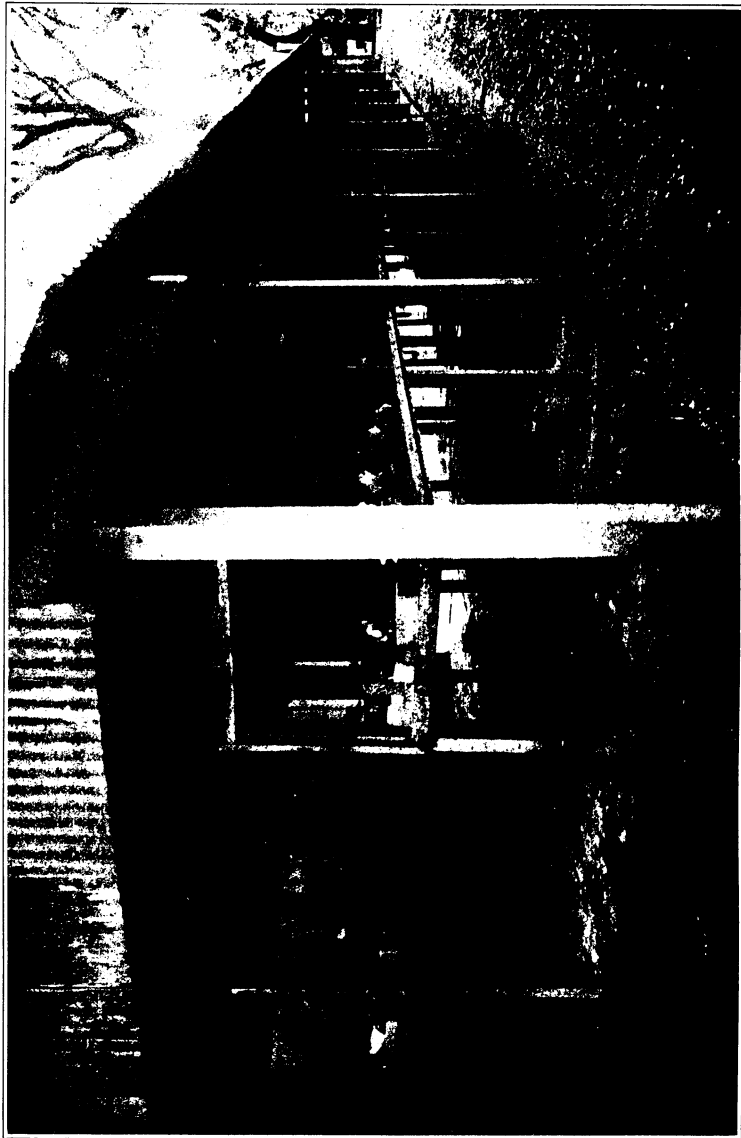


PLATE 2.



THE ABO-ABO SOIL OF OCCIDENTAL NEGROS

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ONE PLATE AND ONE TEXT FIGURE

INTRODUCTION

At the meeting of the Philippine Sugar Association in 1926, the question regarding the abo-abo soil found in Occidental Negros was discussed with considerable interest. Abo-abo is the Visayan name for ash, and the soil is so called because the surface soil has an ashlike appearance. During the course of the discussion contradicting opinions were heard. It was claimed among other things that the main factor responsible for the unproductivity of the so-called abo-abo soil was the lack of organic matter. On the other hand, my preliminary finding, based on the results of analysis made of one sample of abo-abo soil, showed the presence of organic matter and nitrogen in considerable amounts. Because of the importance of this subject from the agricultural and the scientific viewpoints, further investigation was undertaken and the results obtained are presented herein.

PLAN OF INVESTIGATION

The present paper deals with the physical, chemical, and biological properties of abo-abo soil. It is hoped that the results from this work may give some clue to the solution of the abo-abo problem as at present found in Occidental Negros. This investigation was started in January, 1927, and has been conducted in accordance with the following plan:

A. Field study.

1. Location of places where abo-abo soil is found.
2. The approximate area in each locality.
3. General study of the field, including its topography, drainage, vegetation, etc.
4. Examination of soil formation.
5. Collection of soil sample from each layer.
6. History of the field, fertilization, cultivation, production, etc.

B. Laboratory studies.

1. Physical studies.
2. Chemical analyses (surface soil).
3. Mechanical analyses (surface soil, subsoil, and substratum).
4. Biological studies.

FIELD STUDIES**NATURE OF ABO-ABO SOIL**

Abo-abo soil is a local name used by the hacenderos in Negros for a type of soil possessing a peculiar characteristic. Abo-abo is found in several places in Negros; the total area of this soil constitutes but a small portion of the entire sugar land of Occidental Negros. It occurs as small patches in the fields, from a fraction of a hectare to 100 hectares or more in extent; however, it is not unusual to find a hacienda of 300 hectares or more practically made up entirely of abo-abo soil.

Abo-abo is a black, loose, porous soil. In the places examined where this type occurs three distinct layers are usually found, as follows: The surface soil, about 15 to 25 centimeters deep, is black, very fine in texture, and exhibits a porous property; the subsoil, about 25 to 35 centimeters deep, is a fine light yellow sand; and the lower stratum consists of gravel and stones mixed with sand.

HISTORY OF EACH FIELD

Hacienda Alejandria, La Carlota.—The abo-abo soil portion of this hacienda covers an area of about 2 hectares. This portion is level, with efficient drainage. This hacienda has been under cultivation for several years, and the cane yields have been very poor, even with the use of fertilizers. Last year (1926), however, Mr. Luis Jalandoni, the owner, used cane varieties Badila and New Guinea 24, instead of Negros Purple as in the previous years, and he claims that a higher yield was obtained from the crop. Because of this result, he is of the opinion that the abo-abo soil problem in Occidental Negros can be solved by variety tests rather than by fertilizer application. Upon examination of the soil by digging to a depth of about 1 meter, at which point further digging met with difficulty on account of the rocky stratum, it was found that the surface soil is 10 to 16 centimeters deep. The subsoil, which is fine, yellowish sand, is 32 to 40 centimeters deep. This layer is followed by coarse gravel.

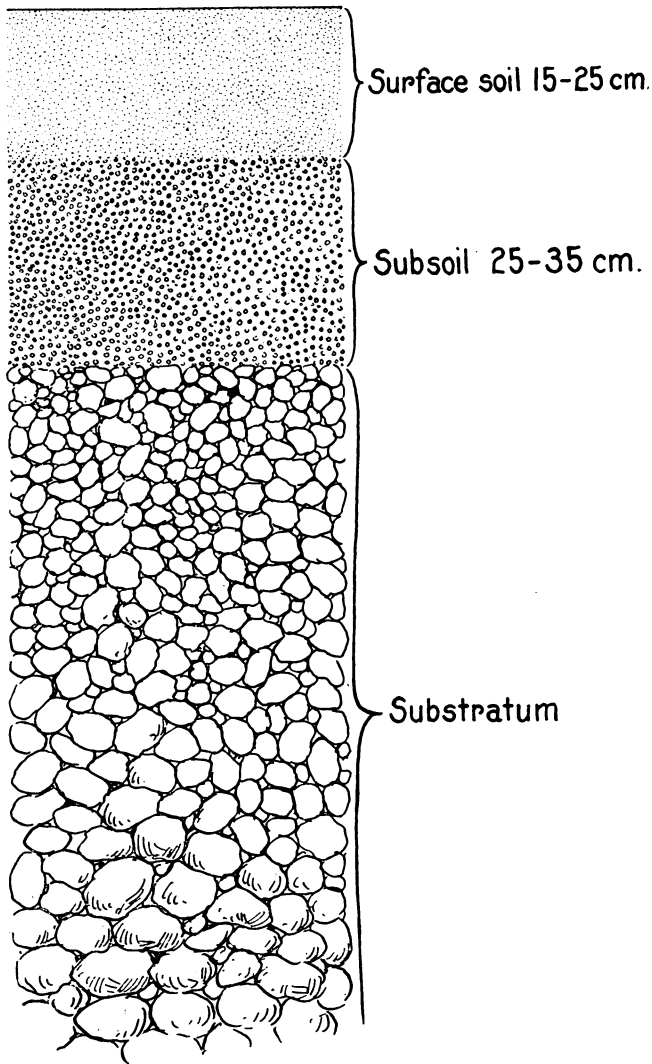


FIG. 1. Profile of abo-abo soil.

Hacienda Caman-og, La Carlota.—The abo-abo soil occurs in different sections of the hacienda. It practically covers about 4 hectares. The owner has found no means of improving this soil. From year to year the canes in this soil are stunted. The yield has been very poor, even with the use of commercial fertilizers. The soil is black, and very loose and fine in texture. The black soil extends to a depth of about 15 to 25 centimeters, and is followed by yellow sand over coarse gravel.

Hacienda Caiñaman, La Carlota.—This hacienda has about 5 hectares of abo-abo soil. It has been noticed that cane in this type of soil grows very poorly. Although fertilizers of different kinds were used yet the yields were very much lower than those obtained from the average field having another type of soil. The soil formation was examined and it was found to possess the same characteristic as that of similar soils previously examined.

Hacienda Conchita, La Carlota.—The abo-abo soil portion of this hacienda is about 25 to 30 hectares. In spite of application of fertilizers of different brands no yield has been obtained. Upon digging the soil it was found that the surface soil, which is black, and loose and fine in texture, is about 6 to 9 centimeters deep. The subsoil consists of sand and gravel and extends to a considerable depth.

Hacienda Jesusa, Bacolod, Murcia.—This hacienda has an area of about 270 hectares, 150 hectares of which are abo-abo. The whole hacienda is slightly rolling land and is all under cultivation. The good portion of the hacienda produces from 60 to 70 piculs of sugar per hectare, while the abo-abo portion gives from 10 to 15 piculs per hectare. In spite of heavy application of commercial fertilizers the abo-abo fields give very poor yields. Upon examination of the soil of the abo-abo portion it was found that the surface soil was only 7 to 9 centimeters deep and that the subsoil was of sand followed by gravel. The several borings made revealed a uniform soil formation.

Hacienda Cabangalan, Hawaiian Philippine.—The soil of the whole hacienda is practically all abo-abo; it has been abandoned for several years, with the exception of a few hectares that are still under cultivation. The yields from the cultivated fields have been very low. Corn was tried beside cane, but the corn yield was also poor. In the uncultivated area grasses are found growing very thinly. It was found that the root system has not penetrated deeper than 4 to 5 centimeters within the surface soil. The surface soil is 15 to 20 centimeters deep; the subsoil, which is yellow sand, extends to a depth of 35 to 40 centimeters, followed by gravel. It was noticed while digging that the surface soil was dry, in spite of the fact that the subsoil was very moist.

LABORATORY STUDIES

In working with a soil of the type of abo-abo the physical, biological, and chemical properties of which are not definitely

known, it is important that a determination of these properties be made for the purpose of deciding which of the factors are directly or indirectly concerned in rendering the soil unproductive. The physical analysis will show whether the soil is a favorable medium for the growing plant and also for lower forms of life the activities of which are directly concerned in transforming the nonsoluble into available plant-food elements. The chemical analysis will show the presence and amount of the necessary elements for plant growth, as well as the presence of toxic compounds containing aluminium, iron, and manganese. These compounds have a detrimental effect on the growth of the plant and will also cause the precipitation of food elements out of soil solution, thus rendering them nonavailable for the use of the plant. The biological analysis will show the presence or absence of the proper microorganisms concerned in the process of formation of available food elements; it will also show the degree of microbiological activities. This point is very important, especially in relation to the crop-producing power of the soil, because there is a certain stage in the period of growth where the plant needs a maximum supply of food and, unless such need be supplied in time, the plant suffers.

All analyses (physical, chemical, and biological) were made in accordance with standard methods. All determinations were made in duplicate.

PHYSICAL TESTS

The results obtained from the physical tests of abo-abo soil are as follows:

Specific gravity:	
Absolute or real	1.85
Apparent	0.52
Pore space, per cent	71.90
Water-holding capacity, per cent	58.23
Rate of percolation, cubic centimeter per minute	0.3
Expansion, per cent	5.0
Rate of evaporation:	
Free water surface, cubic centimeter per minute	0.16
Soil surface, cubic centimeter per minute	0.13
Hygroscopic moisture, per cent	12.48

The above figures clearly show the peculiar characteristic of the abo-abo soil. The soil is very light, having an apparent specific gravity of 0.52, which is very low as compared with that of an average normal soil. The percentage of pore space obtained indicates that this soil is very loose, thus encouraging

excessive evaporation; the rate is 0.13 cubic centimeter per minute while the free water surface under the same conditions is 0.16 cubic centimeter per minute. The water-holding capacity, 58.23 per cent, is considered normal, when compared with the results obtained from a series of tests conducted with normal soils. The rate of percolation is high, 0.3 cubic centimeter per minute. Of course, this result is to be expected of porous soil. The rate of expansion, however, is far above that of the average soils of normal productivity.

CHEMICAL ANALYSES

The results of chemical analysis obtained from a number of determinations are the following:

	Per cent.
Total nitrogen	0.529
Soluble nitrogen	Trace
Nitrate nitrogen	Trace
Ammonia nitrogen	Nil
Total phosphoric anhydride (P_2O_5)	0.866
Total potash (K_2O)	0.602
Aluminium oxide (Al_2O_3)	20.03
Iron oxide (Fe_2O_3)	7.05
Manganese oxide (Mn_2O_3)	0.15
Acidity	0.04
Humus	23.20
Alpha, HCl insoluble	11.06
Beta, HCl soluble	12.14
Total carbon	13.19
Inorganic	0.02
Organic	13.17
Organic matter	22.98

The chemical analysis shows that abo-abo soil possesses a high potential fertility, even higher than that of most Philippine productive soils. The most essential plant food elements, such as nitrogen, phosphorus, and potassium, are present in sufficient amounts for at least normal production. The soil is found to contain considerable amounts of aluminium and iron compounds. Judging from the nature of the soil solution, which is acidic in reaction (0.04 per cent of titrable acid), part of these compounds is rendered soluble. It has been proven by various investigations that the presence of a sufficient amount of soluble aluminium and iron compounds in the soil produces a toxic effect on crops. Whether this is the case in abo-abo soil I am not in a position to say without further investigation on the subject.

According to the method of humus determination by Selman A. Waksman,¹ two forms of humus are present in abo-abo soil; the alpha, or hydrochloric acid insoluble, and the beta, or hydrochloric acid soluble. This soil was found to contain 11.06 per cent alpha humus and 12.14 per cent beta humus.

The total carbon analysis shows a small amount of inorganic carbon, which is mostly carbonate carbon, but a very high amount of organic carbon, 13.17 per cent, which indicates the presence of a great quantity of organic matter. Upon computation from the organic carbon obtained the soil was found to contain 22.98 per cent organic matter.

MECHANICAL ANALYSIS

	Per cent.
Surface soil, 15-25 centimeters:	
Coarse sand, 1-0.5 millimeter	1.0
Medium sand, 0.5-0.25 millimeter	9.9
Fine sand, 0.25-0.10 millimeter	27.6
Very fine sand, 0.10-0.05 millimeter	18.7
Silt, 0.05-0.005 millimeter	37.3
Clay, 0.005 millimeter	5.5
Subsoil, sandy, 25-35 centimeters:	
Coarse sand	22.4
Medium	29.7
Fine and very fine sand	47.9
Silt	Nil
Clay	Nil
Substratum, 35 centimeters:	
Gravel	98.0
Coarse and medium sand	2.0
Fine sand	Nil
Very fine sand	Nil
Silt	Nil
Clay	Nil

The analysis shows that the surface soil contains a very small amount of clay. From the standpoint of tillage it is one of the most desirable types of soil to work; but with regard to moisture content it may not be a good type of soil, because of its high rate of evaporation. The physical study of both the subsoil and the substratum shows that there is little or no capillary connection between the surface soil and the water below as the two lower strata are mostly sand and gravel. Under these conditions, no matter how much the yearly pre-

¹ On the origin and nature of soil organic matter or soil humus: II. Method of determining humus in the soil, *Soil Sci.* 22 (1926) 22.

precipitation, this type of soil will always lack available moisture as after rains the water readily percolates through the soil and is not drawn up again by capillary attraction as the surface soil dries.

BIOLOGICAL ANALYSIS

A comparative study to determine the microbiological property, especially the nitrifying power, consisted in incubating a definite amount of treated and untreated soil for thirty days under optimum moisture and temperature conditions. During the period of incubation both the moisture and the temperature were kept constant. After thirty days' incubation the soil was analyzed for nitrate nitrogen, and the amount of nitrification was computed from the nitrate nitrogen obtained as compared with the nitrogen added. The conditions under which the experiment was conducted are as follows:

- Soil without treatment.
- Soil treated with lime (CaCO_3).
- Soil treated with organic nitrogenous material (copra cake).
- Soil treated with organic nitrogenous material and lime.
- Soil treated with inorganic nitrogenous material (ammonium sulphate).
- Soil treated with inorganic nitrogenous material and lime.

Several determinations were made for each condition or set of conditions and the figures reported herein represent the average result of all the determinations for each set (Table 1).

TABLE 1.—Results of biological analyses of *abo-abo* soils.

Laboratory No.	Treatment.	Nitrate nitrogen mg. per 100 g. soil.	Added nitrogen nitrified.
			<i>Per cent.</i>
100-110.....	100 grams soil.....	Trace.	
120-290.....	100 grams soil + 0.2 grams lime (CaCO_3)	0.3011	0.06, of original nitrogen.
300-490.....	100 grams soil + 1.2 grams copra cake + 0.2 grams lime.....	0.3279	0.81
500-590.....	100 grams soil + 0.2 gram ammonium sulphate + 0.2 gram lime.	1.454	3.46
600-690.....	100 grams soil + 1.2 grams copra cake.....	Trace.	
700-790.....	100 grams soil + 0.2 gram ammonium sulphate.....	Trace.	

When ammonium sulphate and copra cake were each applied to the soil their nitrogen content was not nitrified after thirty days' incubation under favorable moisture and temperature

conditions. When soil alone was incubated under the same favorable conditions, a very small degree of nitrification was noticed. However, with the addition of lime to the soil the nitrification process was accelerated to a small degree. For instance, the original nitrogen of the soil was nitrified 0.06 per cent, that of copra cake 0.81 per cent, and that of ammonium sulphate 3.46 per cent. The degree of nitrification of ammonium sulphate is much higher than that of copra cake, but such a result is to be expected; it simply shows that the two materials differ in the number of stages of decomposition through which they pass in the process of nitrification. Copra cake must pass through at least five stages before nitrate production is accomplished, while ammonium sulphate must pass through only three stages.

The results obtained indicate that the microbiological property of this soil is far below normal. The conversion of unavailable nitrogen is very much slower than it is in other soils, and therefore the amount of available converted nitrogen is even smaller than the minimum intake of this element by any ordinary crop.

GENERAL DISCUSSION OF RESULTS

A careful study of the results from the foregoing experiments and observations shows that one of the outstanding factors responsible in rendering the abo-abo soil unproductive is the physical property of the surface soil which encourages excessive evaporation and a high rate of percolation, in combination with the unusual soil formation of sandy subsoil and gravel substratum. The above phenomena indicate very clearly that the surface soil will always be deprived of available water. During a heavy precipitation all the excess water is being percolated below and, by virtue of the characteristic of the lower strata, this percolated water has little chance to go up and maintain the equilibrium of available water supply in the surface soil during the period of excessive evaporation, thus resulting in the permanent wilting of the crop.

From the chemical consideration it is quite unusual for such a soil as abo-abo, the total organic matter content of which is high, to exhibit a high rate of evaporation; but it should be borne in mind that there are two forms of organic matter (natural and soil organic matter), and both forms may exist in the soil at the same time. The natural organic matter consists of ani-

mal and plant residues, which when added to the soil undergo rapid decomposition, while the soil organic matter is derived from organic substances mostly from plant life and, owing to unfavorable environment conditions, it becomes mineralized and is resistant to the action of soil microorganisms for further decomposition. A soil may contain a considerable amount of total organic matter; but, if it is mostly the resistant form, the physical property of the soil with regard to the retention of moisture will not be materially improved. The low percentage of clay in abo-abo soil indicates the lack of colloidal materials which, when present, help to check the maximum loss of water from the soil.

A series of biological tests shows that the reaction of the soil hinders the activities of the different organisms concerned in the processes of decomposition for the conversion of nonavailable food elements into a state in which they become available for the plant.

SUMMARY

The results of all the tests and analyses conducted with the abo-abo soil reveal the following fundamental facts:

1. Due to the peculiar physical characteristic of the surface soil, the rate of evaporation and percolation become high, thus greatly reducing the available water supply in the surface soil for the use of the plant.

2. During the period of low precipitation and high evaporation, the available water supply in the surface soil is limited, because of the unusual formation of the lower strata—sandy subsoil and gravel substratum—which prevents the transmission of water by capillarity from below to the surface soil. Under this condition the crop suffers, not only from lack of moisture, but also from serious lack of plant food.

3. The porosity of the abo-abo soil is primarily due to the absence of a sufficient amount of colloidal materials. The presence of colloidal materials increases the retentive and absorptive power of a soil.

4. The different soil organisms concerned in the formation of available plant foods are rendered inactive by the unfavorable reaction of the soil solution present in abo-abo soil.

5. The limited water supply in the surface soil and the unfavorable soil reaction are the factors responsible for rendering any commercial-fertilizer application in abo-abo soil ineffective.

RECOMMENDATIONS

After taking into consideration the outstanding factors directly concerned with the abo-abo problem, the following recommendations are offered in the hope of improving the productive capacity of abo-abo lands:

1. During the wet season of the year the land should be seeded with legumes, especially mongo, cowpeas, or soy bean. When the plants begin to flower, ground limestone should be applied at the rate of 1 to 2 tons per hectare; the legumes should then be plowed under, the plowing to be as deep as possible. With the proper amount of moisture present in the soil the green organic matter will undergo practically complete decomposition after three or four weeks' time.

2. In places where mud press is plentiful, the application of 2 to 3 tons of this per hectare will materially improve the physical property of abo-abo soil. The mud press should be spread over the land and then plowed under. With the application of mud press the colloidal materials of abo-abo soils will be increased, thus increasing the retentive and absorptive power of the soil.

3. The use of ammonium sulphate and nitrate of soda, supplemented with green manure, may prove effective in this type of soil.

4. The use of lime alone helps materially in improving the abo-abo soil conditions, but has not been as effective as when applied in combination with green manure or nitrogenous organic materials.

ILLUSTRATIONS

PLATE 1. THE LAYERS OF ABO-ABO SOIL

- FIG. 1. Substratum, gravel.
2. Subsoil, sand, 25 to 35 centimeters deep.
3. Coarse materials mixed with surface soil.
4. Surface soil, 15 to 25 centimeters deep.

TEXT FIGURE

- FIG. 1. Profile of abo-abo soil.

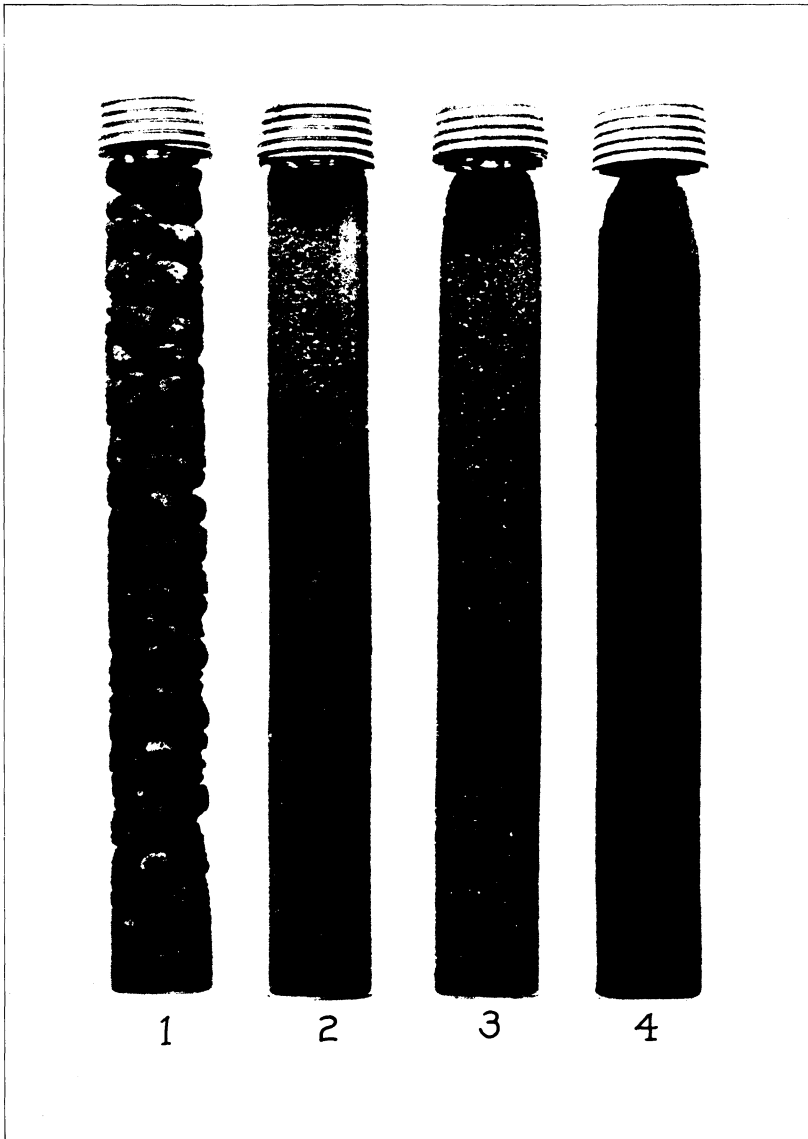


PLATE 1. THE LAYERS OF ABO-ABO SOIL.

Fig. 1. Substratum, gravel; 2, subsoil, sand, 25 to 35 centimeters deep; 3, coarse material mixed with surface soil; 4, surface soil, 15 to 25 centimeters deep.

CHAULMOOGRYL DERIVATIVES OF LACTATES AND SALICYLATES

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and

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Various derivatives of chaulmoogric acid, such as esters and anilides, have been made from chaulmoogra oil. In the present investigation a few double esters containing the chaulmoogra radical were prepared. The method of preparation consisted in treating the esters of lactic and salicylic acids with the acid chloride of chaulmoogric acid. The compounds thus obtained were chaulmoogryl derivatives of lactates and salicylates. Our results seem to indicate that these substances can be prepared rather easily, but they have a tendency to decompose in hot summer weather unless they are kept in a cool place. The new compounds prepared in this research will be tested for their therapeutic value.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was prepared from the seeds of the Philippine variety of chaulmoogra known as *Hydnocarpus alcalae* C. de Candolle. Dr. H. I. Cole, of the Philippine Bureau of Health, very kindly shipped a supply of the oil to us from the Culion Leper Colony.

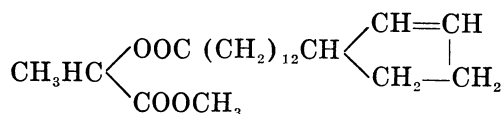
The chaulmoogric acid and acid chloride of chaulmoogric acid were prepared according to the procedure used by Santiago and West ¹ in a recent investigation of chaulmoogra anilides. Chaulmoogra oil (600 grams) was saponified with alcoholic potassium hydroxide (200 grams dissolved in 80 cubic centimeters of water and 800 cubic centimeters of aldehyde-free alcohol). The mixture was heated (reflux) on a water bath for about four hours, after which the excess alcohol was removed by distillation.

¹ Philip. Journ. Sci. 33 (1927) 265.

The residual soaps were decomposed with dilute sulphuric acid (1:4) and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resins were separated from the acid by filtering. The gasoline was then removed by distillation and the residue crystallized several times from alcohol (95 per cent). The melting point was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid (20 grams) with phosphorus trichloride (2.2 cubic centimeters). The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid (about 18 grams) was allowed to drop slowly into an ester of lactic or salicylic acid.

CHAULMOOGRYL METHYL LACTATE



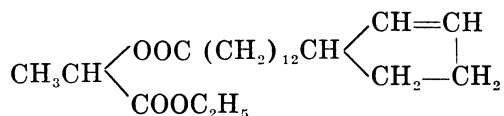
Methyl lactate (3.8 cubic centimeters) was treated with the acid chloride of chaulmoogric acid (about 18 grams) prepared as previously described. The mixture was heated (reflux) in a Crisco bath at a temperature of about 120 to 140° C. until there was no further evolution of hydrogen chloride gas. During the heating a tube containing calcium chloride was placed in the top of the condenser to prevent the access of atmospheric moisture. It required about four days to complete the reaction. The reaction product, when cooled, changed to a black solid mass. This was then crystallized from methyl alcohol to which bone black was added to decolorize the solution. About 5 grams of anhydrous sodium sulphate were also added to the solution to remove small quantities of colloidal matter which appeared to be present. The product was then crystallized twice from methyl alcohol containing bone black. The excess alcohol was evaporated and removed by exposing the solution to the breeze of an electric fan. The crystals obtained from the concentrated solution gave a melting point of from 51 to 54° C. The yield

was 10 grams, which was equivalent to about 38 per cent of the theoretical yield.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{22}H_{38}O_4$	72.13	10.38
Found	71.39	9.61

CHAULMOOGRYL ETHYL LACTATE

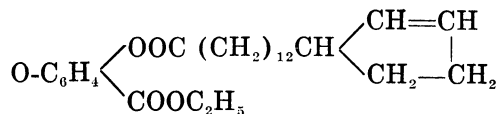


Ethyl lactate (4.5 cubic centimeters) was treated with the acid chloride of chaulmoogric acid (about 18 grams) as in the previous experiment. The mixture was heated (reflux) in a Crisco bath at a temperature of 140 to 160° C. until there was no further evolution of hydrogen chloride gas. The time required to complete the reaction was about four days. The black reaction product was crystallized once from methyl alcohol containing bone black and anhydrous sodium sulphate and several times from methyl alcohol containing only bone black. When the solution was concentrated by evaporation, the crystals obtained gave a melting point of from 54 to 57° C. The yield was 9 grams, which was equivalent to about 33 per cent of the theoretical yield.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{23}H_{40}O_4$	72.63	10.53
Found	73.39	10.40

CHAULMOOGRYL ETHYL SALICYLATE



As we did not have any ethyl salicylate in our stock room we prepared this compound by dissolving salicylic acid (30 grams) in absolute alcohol (100 cubic centimeters) and adding 8 cubic centimeters of concentrated sulphuric acid to the solution. The mixture was heated (reflux) on a water bath for about two hours, after which the excess alcohol was removed

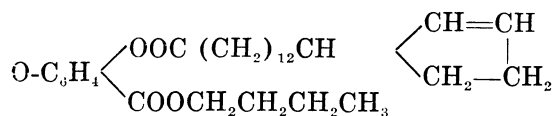
by distillation. The reaction product was then poured into about 150 cubic centimeters of water and neutralized with sodium carbonate solution. The ester was then extracted with ether and the ether extract dehydrated with anhydrous sodium sulphate. After filtering out the dehydrating agent, the ether was removed by distillation. The ester was then distilled and the fraction boiling between 220 and 227° C. was collected.

Chaulmoogryl ethyl salicylate was made by treating ethyl salicylate (6 cubic centimeters), prepared as previously described, with the acid chloride of chaulmoogric acid (about 18 grams). The mixture was heated (reflux) in a Crisco bath at a temperature of about 160 to 180° C. The reaction product when purified consisted of crystals which melted at 48 to 51° C. The yield was 5 grams, which was equivalent to about 16 per cent of the theoretical yield.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{27}H_{40}O_4$	75.70	9.35
Found	74.98	9.32

CHAULMOOGRYL N-BUTYL SALICYLATE



In the preparation of this compound, the normal butyl ester of salicylic acid was made first, after which this substance was treated with the acid chloride of chaulmoogric acid. The normal butyl ester of salicylic acid was made in the following manner: Salicylic acid (45 grams) was dissolved in absolute normal butyl alcohol (150 cubic centimeters) and the solution was treated with 12 cubic centimeters of concentrated sulphuric acid. The mixture was heated (reflux) and allowed to boil gently for about two hours. The reaction product was then treated with a concentrated solution of calcium chloride until all the excess butyl alcohol was precipitated. The mixture was then extracted with ether and the excess acid was neutralized with sodium carbonate solution. The ether extract was dehydrated with anhydrous sodium sulphate and the ether removed by distillation. The ester was distilled in vacuum (about 10 millimeters pressure) and the fraction boiling between 136 and 138° C. was collected.

Chaulmoogryl *n*-butyl salicylate was prepared by treating 4 cubic centimeters of the freshly prepared *n*-butyl salicylate with the acid chloride of chaulmoogric acid (about 18 grams). The method of preparation was about the same as that used for preparing the other double esters. The mixture was heated (reflux) in a Crisco bath at a temperature of about 180 to 190° C. for five days. The reaction product when purified consisted of crystals which melted at from 49 to 50° C. The yield was 9 grams, which was equivalent to about 27 per cent of the theoretical yield.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{20}H_{44}O_4$	76.32	9.65
Found	75.71	9.66

In addition to the chaulmoogryl lactates and salicylates recorded in this paper, four other chaulmoogryl salicylates were prepared. They were the chaulmoogryl methyl, phenyl, amyl, and isoamyl salicylates. The method of preparation was similar to that employed in making the chaulmoogryl butyl and ethyl salicylates. Unfortunately, these substances were made during the hot season and, shortly after they were purified, they began to decompose slowly and acquire a slightly rancid odor. When these substances were analyzed to check the formulas, the percentage of carbon and hydrogen found was about 3 per cent lower than the theoretical percentage of these constituents. Since these impure compounds gave unsatisfactory analyses, the results are not included in this paper.

SUMMARY

Two chaulmoogryl lactates and two chaulmoogryl salicylates were prepared in this investigation; namely, chaulmoogryl methyl lactate, chaulmoogryl ethyl lactate, chaulmoogryl ethyl salicylate, and chaulmoogryl *n*-butyl salicylate.

Chaulmoogryl methyl lactate was made by treating methyl lactate with the acid chloride of chaulmoogric acid. Chaulmoogryl ethyl lactate was obtained in a similar manner by the interaction of ethyl lactate and the acid chloride of chaulmoogric acid. By treating ethyl and *n*-butyl salicylates with the acid chloride of chaulmoogric acid chaulmoogryl ethyl salicylate and chaulmoogryl *n*-butyl salicylate were obtained.

Our results indicate that these double esters can be prepared rather easily, but they have a tendency to decompose in hot summer weather unless they are kept in a cool place.

A PHYTOPHTHORA DISEASE OF SANTOL SEEDLINGS

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FOUR PLATES AND FOUR TEXT FIGURES

In August, 1924, a serious disease of santol seedling, *Sandoricum koetjape* Burm. f. (*S. indicum* Cav.), was noted in seed beds at the Singalong Experiment Station of the Bureau of Agriculture, Manila, P. I. The disease is caused by a species of *Phytophthora* hitherto not reported on this host and, as far as known, occurs only at that place. It is outwardly manifested by blights on the different parts of the young seedlings, which finally collapse and decay. The same trouble recurred the following year with so much virulence that it attracted much attention.

ECONOMIC IMPORTANCE OF THE DISEASE

The extent of damage to the santol seedlings has now been observed at the Singalong station for two successive years. Actual counts made in a seed bed 1.35 by 1.5 meters showed that 90 per cent of the seedlings were either dead or dying. In another, much larger seed bed, 1.35 by 6.2 meters, all of the seedlings showed the disease, the majority of them being dead and the remainder spindling. The two varieties of sweet santol, locally known as *bulakan* and *lacao*, were both badly infected.

In a neighboring seed bed of Para rubber plants, *Hevea brasiliensis* (HBK.) Muell.-Arg., a fungus causing a similar disease was incidentally encountered and the organisms were isolated. This was later found to be produced by the fungus that causes the santol disease.

SYMPTOMS OF THE DISEASE

The disease manifests itself at a distance as a leaf blight followed by collapse of the plant. Close examination shows depressed lesions on the petioles, stem, and cotyledons (Plate 1). In badly diseased seed beds frequently only the stumps of

the seedlings remain. The first point of attack, which can be readily recognized by the typical lesions, may occur on any part of the plant above the ground.

On the leaf.—The first visible symptoms of the disease when starting on the leaves are small brown specks varying from circular to irregular in shape. Any part of the leaf may be attacked, but the leaf veins, midrib, and petiole seem to be the parts more easily affected. As the spots enlarge they become more or less greenish brown and dry up like parchment. A great part of the leaf area may thus become brown, and in some cases the entire leaf may curl up. The drying of the diseased portions takes place during sunny days following heavy rains. Under very moist conditions, as when inoculated plants are placed under bell jars, a kind of wet decay may develop rather than a blight, and defoliation may also be more rapid. Regardless of the point of origin on the leaf, the disease progresses more rapidly toward the stem, thus readily involving the tender shoots. In case the first infections occur on the petioles, the leaves fall off as soon as the disease has invaded the point of their attachment to the stem, although overlapping leaves in crowded plantings are frequently found fastened together by fungus hyphæ.

On the stem.—Lesions on the stem appear as elongated greenish brown depressions, commonly found below and above the cotyledons. These may cause a conspicuous general wilting of the leaves occasioned by interference with the water supply.

On the cotyledons.—These parts, from which the young plants obtain their food supply before the appearance of the leaves, remain firmly attached for a considerable length of time and are very readily attacked by the fungus. In fact, many of the cotyledons were found diseased, the aërial growth of the fungus on them being very evident (Plate 2, fig. 1). As they shrivel the disease invades the stem.

CONDITIONS FAVORING DEVELOPMENT OF THE DISEASE

The disease has been repeatedly observed during rainy days followed by warm weather, the conditions during the month of August being very favorable to its rapid development. At this time of the year the weather is warm and moist. Crowded planting increases the severity of the infection. Plants grown in poorly drained plots under the shade of bamboo slats were seriously damaged.

DISSEMINATION OF THE FUNGUS

The repeated occurrence of the disease in the seed beds, but never in the seed flats placed on benches about a meter above the ground and protected with a roof, indicates that rain has an important bearing upon the spread of the fungus, since the spores may be readily carried in the dropping water or may be splashed up on the plants from the soil. Cultivation and other operations in the seed beds will also spread the disease if no precautions be taken, while close planting facilitates the contamination of the neighboring plants. Under such conditions leaves overlap and come in contact, thus offering easy passage for the fungus from one leaf to another. This is readily evidenced by the frequent binding together of diseased leaves by the fungus mycelia. Insects may also act as carriers of the disease, and the use of seedlings obtained from infected seeds may likewise spread the disease to other places.

ISOLATION OF THE CAUSAL ORGANISM

A species of *Phytophthora* and a number of other fungi were isolated from the diseased areas, but inoculations have shown that only the *Phytophthora* is capable of reproducing the disease. The isolations were made by cutting out with a flamed scalpel portions of young lesions occurring on shoots, stems, and cotyledons of diseased plants. After sterilizing the surface of the portions by immersing for twenty to thirty seconds in a 1:1000 mercuric chloride solution, the portions were rinsed three times in sterile water and plated on hard potato-glucose agar +1 or on corn meal. A very uniform growth of fungus such as *Phycomycetes* produce was obtained in almost all of the plantings, and transfers were made from there which exhibited the most uniform appearance. The growth was most luxuriant on oatmeal agar prepared according to Clinton's⁽¹⁾ method as modified by Rosenbaum.⁽²⁾ Pure cultures were then obtained by using the plate-dilution method, only single spore growths previously located under the microscope having been selected. In this manner the *Phytophthora* was repeatedly isolated during the month of August for two successive years, 1924 and 1925.

PROOF OF PATHOGENICITY TO SANTOL

Santol seedlings of the bulakan and lamao varieties were grown in pots of sterilized soil. These were used for the inoculation experiments.

On September 8, 1925, seedlings in one pot were inoculated by placing bits of fungus hyphæ on the young shoots and some on the leaves and cotyledons. Bits of agar containing the fungus mycelium were also used on some of the plants. These inoculated plants were kept under a bell jar for three days. Check plants were also set out under the same conditions. On September 11, three days after the inoculation, infection was very evident in all of the inoculated plants. Characteristic brown lesions on the shoots (Plate 3, fig. 2), petioles, and cotyledons were very clearly shown, particularly on the cotyledons, where the fluffy aërial growth of the fungus was conspicuous (Plate 3, fig. 1). Quicker infection was obtained where hyphæ in bits of agar were employed. The controls or checks remained normal (Plate 2, fig. 3).

In one week the inoculated plants had very few leaves left and most of them were dead (Plate 2, fig. 2). After the leaves had fallen to the ground and decayed the disease progressed downward on the stem. The plants inoculated on the cotyledons succumbed more quickly, wilting as soon as the infection developed far enough on the stem. All the inoculated plants showed marked blighting nearly identical to that occurring naturally in the seed beds.

Another set, consisting of four pots of santol seedlings, was inoculated in the same manner except that the plants were kept under very moist conditions by placing vessels of water beside the pots under the bell jars. Under these conditions the disease developed much more quickly and the plants were completely defoliated in a short time. The disease here was in the nature of a wet rot rather than a typical blight.

On July 29, 1926, another lot of santol seedlings grown in large pots of sterilized soil was inoculated. The seedlings in the three pots were inoculated in the same manner as in previous years and kept under bell jars for three days. The checks were also set out under the same conditions. All of the plants were then kept under partial shade. The results were the same as those in the previous inoculations.

In all cases *Phytophthora* was reisolated from the inoculated plants, while the controls remained normal.

INOCULATION OF OTHER SPECIES OF PLANTS WITH THE SANTOL PHYTOPHTHORA

Several species of the genus *Phytophthora* are known to attack a large number of hosts. In order to see if this is true

with respect to the santol *Phytophthora*, seedlings of various plants grown in sterilized soil in pots were inoculated with the fungus. Checks were always kept under the same conditions as those governing the inoculated plants. Reisolation of the fungus from the infected plants was made in every case.

The seedlings were found to be susceptible in the following order:

Hevea brasiliensis (HBK.) Muell.-Arg. (Para rubber); blight on shoot.
Brassica juncea (Linn.) Coss. (pechay); slight wet rot.
Raphanus sativus Linn. (radish); slight wet rot.
Lycopersicum esculentum Mill. (tomato); very slight damping off.
Solanum melongena Linn. (eggplant); very slight damping off.
Vigna sesquipedalis Linn. (sitao); infection confined to wounds.
Phaseolus sp. (bean); infection confined to wounds.
Pisum sativum Linn. (chicharo); no infection.
Cucurbita maxima Dusch. (squash); no infection.
Momordica charantia Linn. (ampalaya); no infection.
Carica papaya Linn. (papaya); no infection.
Beta vulgaris Linn. (beet); no infection.

As shown by the results of these cross inoculations the santol *Phytophthora* does not appear to affect many species of plants.

DESCRIPTION OF THE FUNGUS

Mycelium.—On various sterilized plant tissues and agars the fungus produces both aërial mycelium and submerged mycelium, the young mycelium being granular and hyaline. Submerged mycelium is much branched or gnarled when grown on hard potato-dextrose agar +1 (Plate 4, fig. 1). Characteristic of the species of *Phytophthora* young hyphæ are cœnocytic and occasionally with streaming granular protoplasm (Plate 4, fig. 2). Aërial mycelia are straight, simple, and uniform in outline, varying from 2 to 8 μ in diameter.

Conidiophores.—The conidiophores are short, somewhat larger than the vegetative hyphæ, hyaline, and granulated when young. They bear from one to four conidia in a conidiophore and measure from 7.4 to 240.5 by 3.3 to 10 μ (Plate 4, fig. 4).

Conidia.—The conidia are small and hyaline to slightly grayish on oat agar. They may be borne either terminally or intercalarily, and are ovate or lemon-shaped, some of them with a prominent papilla (Plate 4, fig. 3). Vacuoles are frequently present. Measurements of 400 conidia from pure cultures on oat agar seven to twenty-one days old were made as recom-

mended by Rosenbaum,(2) and these conform closely to those for *Phytophthora phaesoli* Thaxter. The results are given in Table 1.

TABLE 1.—*Distribution of lengths and widths of conidia of the Phytophthora from santol into size classes having a difference of 2 microns.*

Length class (in microns).	Number of conidia.	Width class (in microns).	Number of conidia.
-----	-----	9.5-11.49	5
-----	-----	11.5-13.49	0
-----	-----	13.5-15.49	3
-----	-----	15.5-17.49	4
17.5-19.49	7	17.5-19.49	26
19.5-21.49	1	19.5-21.49	25
21.5-23.49	11	21.5-23.49	61
23.5-25.49	9	23.5-25.49	58
25.5-27.49	8	25.5-27.49	93
27.5-29.49	5	27.5-29.49	41
29.5-31.49	37	29.5-31.49	57
31.5-33.49	27	31.5-33.49	21
33.5-35.49	23	33.5-35.49	2
35.5-37.49	54	35.5-37.49	4
37.5-39.49	30	-----	-----
39.5-41.49	61	-----	-----
41.5-43.49	22	-----	-----
43.5-45.49	51	-----	-----
45.5-47.49	8	-----	-----
47.5-49.49	27	-----	-----
49.5-51.49	3	-----	-----
51.5-53.49	10	-----	-----
53.5-55.49	1	-----	-----
55.5-57.49	2	-----	-----
57.5-59.49	0	-----	-----
59.5-61.49	0	-----	-----
61.5-63.49	2	-----	-----
63.5-65.49	0	-----	-----
65.5-67.49	1	-----	-----
-----	400	-----	400

As shown in Table 1 the lengths of 400 conidia range from 17.5 to 67.49 μ , and the widths from 9.5 to 37.49 μ ; however, most of the lengths fall between 21.5 and 53.49 μ , and most of the widths between 17.5 and 33.49 μ . In the case of the lengths it is interesting to note, moreover, that approximately 76 per cent fall between 29.5 and 45.5 μ , while approximately 77 per cent of the widths range between 21.5 and 31.5 μ . The greatest number in any one class fall between 39.5 and 41.49 μ in length and between 25.5 and 27.49 μ in width. The average size, based on 400 measurements, is $35.7 \times 25.2 \mu$. Text figs. 1 and 2 are graphic representations of these measurements.

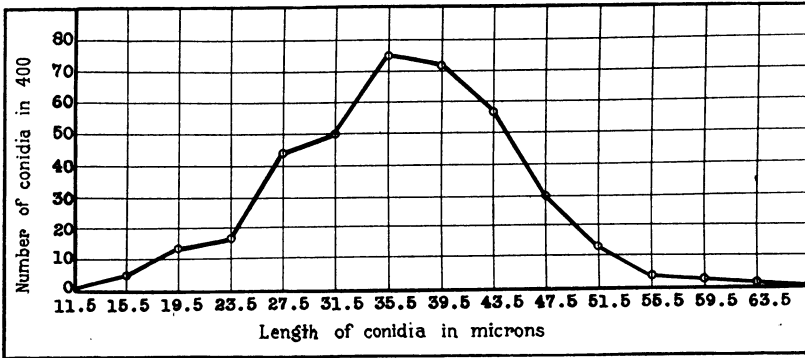


FIG. 1. Variation in the length of conidia.

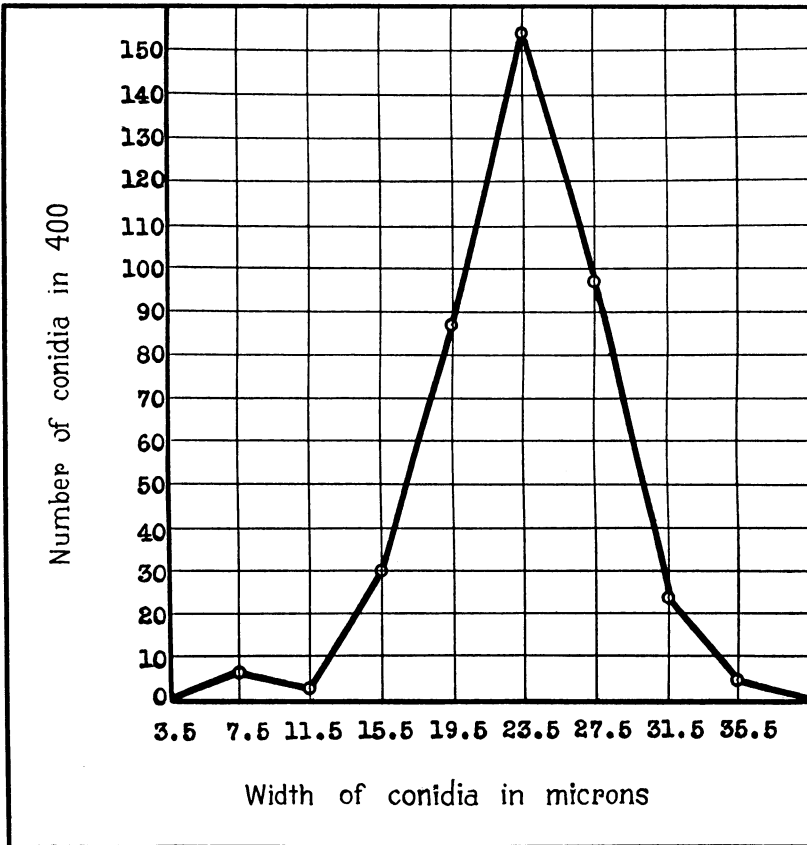


FIG. 2. Variation in the width of conidia.

TABLE 2.—Ratio of length to width of 400 conidia arranged in classes having a range of 0.09 micron.

Ratio class.	Conidia.	Ratio class.	Conidia.
1.05-1.14	7	1.95-2.04	7
1.15-1.24	37	2.05-2.14	0
1.25-1.34	65	2.15-2.24	5
1.35-1.44	68	2.25-2.34	3
1.45-1.54	61	2.35-2.44	2
1.55-1.64	56	2.45-2.54	2
1.65-1.74	52		
1.75-1.84	22	Total	400
1.85-1.94	12		

It will be seen in Table 2 that the ratios of length to width of 400 conidia fall between 1.05 and 2.54; most of them, however, fall between the ratios of 1.15 and 1.94, while the greatest number in any one class have a ratio of length to width falling between 1.35 and 1.44. The mean ratio of the santol *Phytophthora* is 1.51, while that of *Phytophthora phaseoli*, according to Rosenbaum,(2) is less than 1.75. A graphic representation of the ratios of length to width of the 400 conidia of the santol *Phytophthora* is given in fig. 3.

Oöspores.—The abundant production of oöspores on oat agar accords well in this respect with the behavior of *Phytophthora phaseoli*. Oöspores were obtained as early as the seventh day on oat agar and were very abundantly produced in ten- to fourteen-day cultures under room conditions at temperatures of 28 to 30° C. They were also produced abundantly on santol agar. When cultures were placed in an ice box with a temperature ranging from 25 to 28° C. the production of these reproductive organs was much earlier than this and more abundant, being formed in two to five days on oat agar.

The color of the oöspores varies from colorless to light brown or bright yellowish brown. The majority are spherical, although some are somewhat ovoid. They are borne in the oögonia and occasionally have one or two vacuoles. The oöspore walls are thick and smooth.

TABLE 3.—Distribution of oöspores of the santol *Phytophthora* into diameter classes having a difference of 2 microns.

Diameter class (in microns).	Oöspores.	Diameter class (in microns).	Oöspores.
9.5-11.49	1	23.5-25.49	91
11.5-13.49	0	25.5-27.49	125
13.5-15.49	4	27.5-29.49	4
15.5-17.49	10	29.5-31.49	2
17.5-19.49	19		
19.5-21.49	27	Total	400
21.5-23.49	117		

Measurements of 400 oöspores showed that their diameters fall between 9.5 and 31.49 μ , as shown in Table 3, although most of them range between 15.5 and 27.49 μ . Most of them have diameters in the class 25.5 to 27.49 μ . Rosenbaum(2) obtained the greatest number of oöspores for *Phytophthora phaseoli* in the

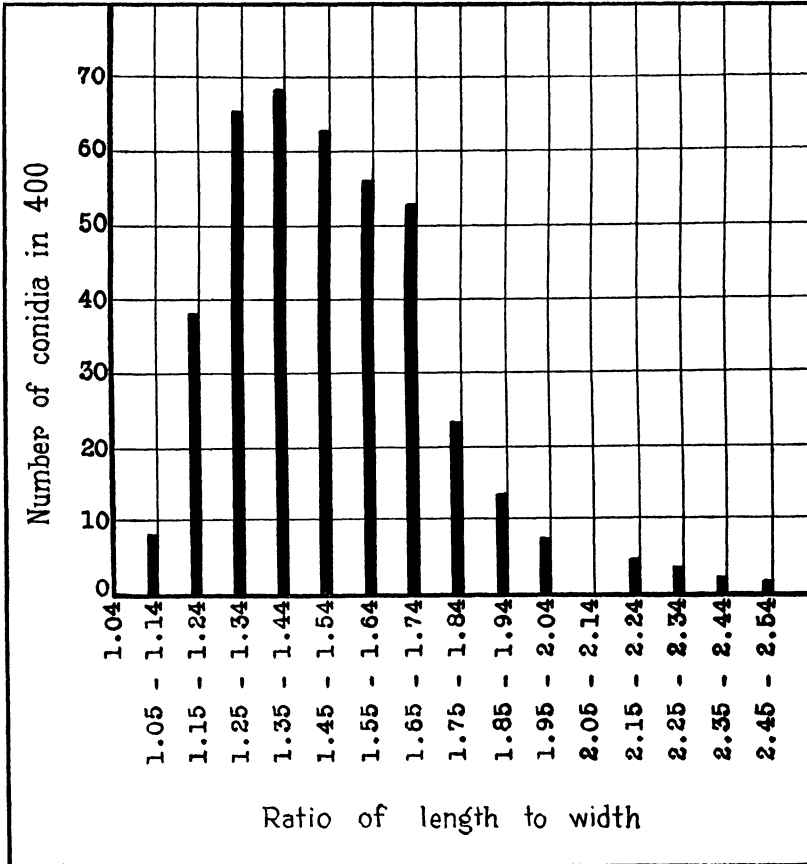


FIG. 3. Diagrammatic arrangement of the ratio classes.

same class, but his range of classes is slightly less. The average diameter is 23.4 μ . A graphic representation of the above measurements is given in fig. 4.

Oögonia and antheridia.—The oögonia are for the most part terminally produced on the branches of hyphæ. The antheridia are prominent and always envelop the base of the oögonial stalk (Plate 4, fig. 5).

GERMINATION OF SPORES

Conidia.—The conidia germinate either by direct production of a germ tube at the base or through the papilla (Plate 4, fig. 6) and by the production of zoöspores (Plate 4, figs. 8 and 9).

The procedure followed in these studies was that employed by Rosenbaum.(2) Cultures of the fungus were made on oat agar in 200-cubic-centimeter Erlenmeyer flasks. At the age of the culture when conidia are known to be present abundantly which in this case is fourteen to thirty days at 28 to 30° C.

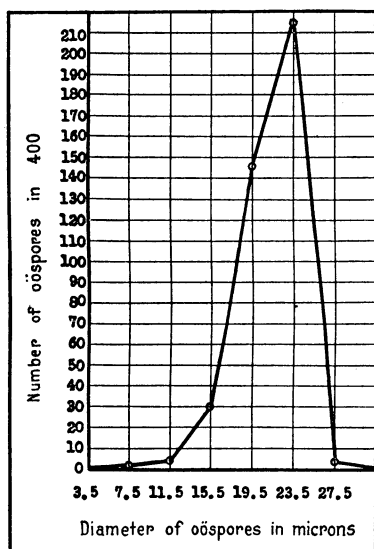


FIG. 4. Variation in the size of oöspores.

and ten days at temperatures of 25 to 28° C., sterile water was carefully poured into the flasks, precautions having been taken to minimize all possible sources of contamination. The culture was then shaken to detach some of the conidia and the resulting spore suspension poured into another sterile flask. The conidia thus obtained were kept at a temperature of 14 to 20° C. by using ice. At the end of four to eight hours zoöspores were produced at these temperatures, while at room temperature they were readily produced in distilled water over night. They pass out through a break in the wall of the conidium, which occurs either at the papilla or at the side (Plate 4, fig. 7). When they are all out nothing but an empty cell remains with no sign of a break. The zoöspores while moving are irregular in shape, but when at rest are almost spherical and measure 4 to 9.3 μ . The greatest number of zoöspores observed in a conidium was 14.

SPORE PRODUCTION AND CULTURAL CHARACTERISTICS ON VARIOUS MEDIA AND STERILIZED PLANT TISSUES

Various sterilized plant tissues and media were used in the study of spore production and growth characteristics of the fungus, observations having been made on cultures ranging in age from one to three weeks. The agars used were potato-

glucose agar, oatmeal agar, and santol-seed agar. The santol-seed agar was prepared according to the following procedure:

Santol seeds, grams	15.32
Grape sugar, gram	1.00
Agar agar, shredded, grams	3.00
Water, cubic centimeters	300

The santol seeds were cleaned and the seed coats removed before weighing. Then they were sliced with a scalpel and ground in a porcelain mortar. After grinding, 3 grams of agar were added and the mixture was placed in a beaker containing 300 cubic centimeters of water. One gram of grape sugar was added after boiling for about five minutes. The solution was then restored to 300 cubic centimeters, filtered through sterilized absorbent cotton, and tubed. It was finally sterilized in an autoclave at 15 pounds pressure for thirty minutes and slanted.

Growth on oatmeal agar.—Abundant aërial growth and abundant oöspores and conidia were produced readily.

Growth on potato-glucose agar +1.—The growth on potato-glucose agar was moderately aërial and the mycelia, particularly the submerged hyphæ, were very much branched and gnarled. Production of a few conidia and oöspores was noted occasionally on four-month-old cultures.

Growth on santol-seed agar.—Santol seed agar gave a fair aërial growth, though it was rather slow, and produced abundant oöspores and conidia. On three-month-old cultures conidia and oöspores were still in a turgid condition. The oöspores in particular were very numerous and were easily seen, owing to their deep yellowish brown color. This is a very suitable medium for the study of the reproductive organs and the mycelium, since these show up very clearly in it.

Growth on steamed rice and plain corn meal.—On steamed rice and corn meal the growth was markedly aërial and on oatmeal very profuse and fluffy, but very few spores were produced.

Growth on liquid media.—On M/100 solution of potassium carbonate prepared according to the formula of Leonian⁽³⁾ transfers of mycelium made from cultures on potato-glucose agar produced sporangia in three days at temperatures of 25 to 28° C. At room temperature, 28 to 30° C., few sporangia were produced even after eight days.

On various sterilized plant tissues exceptionally abundant conidia and a few oöspores were produced on pineapple-fruit cylinders; the growth was somewhat slimy and submerged. The conidia, however, were not typical of the genus *Phytophthora*.

Most of them were much elongated, pointed, or spear-shaped. On mango-fruit cylinders abundant conidia of the same shape were obtained. On papaya cylinders a few spores also of this shape were produced. Table 4 presents all of the results on spore production.

TABLE 4.—*Production of spores of the santol Phytophthora on various media and sterilized plant tissues.*

Medium.	Spores produced after—		
	One week.	Two weeks.	Three weeks.
Potato-glucose agar + 1.	Very few conidia; no oöspores or chlamydospores.	A few conidia; no other spores.	Abundant conidia; no oöspores or chlamydospores.
Rice (steamed) ----	A few conidia; no oöspores or chlamydospores.	A few conidia and oöspores.	None.
Corn meal -----	None-----	A few conidia-----	Do.
Oatmeal -----	A few conidia; abundant oöspores, oögonia, and antheridia.	A few conidia; abundant oöspores.	Abundant oöspores; no conidia.
Sugar-cane cylinder..	Abundant conidia; no oöspores.	Abundant conidia----	Abundant conidia; a few oöspores.
Banana cylinder ----	None-----	None-----	None.
Pineapple fruit cylinder.	Abundant conidia only	Abundant conidia; no other spores.	Abundant conidia; a few oöspores.
Oatmeal agar-----	Abundant conidia and oöspores.	Abundant oöspores; a few conidia.	Abundant oöspores; a few conidia.
Bean seeds (steamed).	None-----	None-----	None.
Santol-seed agar ----	Abundant oögonia and antheridia; few oöspores and conidia.	Abundant oöspores and conidia.	Abundant oöspores; a few conidia.
Santol seeds-----	Very few conidia; no other spores.	A few oöspores; no other spores.	Abundant oöspores; no conidia.
Papaya cylinders----	A few conidia and oöspores.	Very few oöspores; no other spores.	Very few oöspores; no other spores.
Potato cylinders----	None-----	None-----	None.

TAXONOMY

The morphological method of Rosenbaum(2) and the physiological key of Leonian(3) for the identification of *Phytophthora* species were followed in the taxonomic study of the santol *Phytophthora*. The conidia are larger than those of *Phytophthora phaseoli* Thaxter described by Rosenbaum,(2) but the mean ratios of length to width are in close agreement. The abundant oöspores with basal antheridia which were easily obtained in

all oat-agar cultures were also very similar in size to those recorded by Rosenbaum for *P. phaseoli*. On an average, the santol *Phytophthora* has oöspores slightly greater in diameter than those of *P. phaseoli*. These differences, however, do not seem of specific significance, in view of the variability within *Phytophthora* species. The santol *Phytophthora* is therefore referred to *Phytophthora phaseoli* Thaxter.

Leonian in his extensive physiological studies of the genus *Phytophthora* proposed to make *P. phaseoli* Thaxter a variety of *P. infestans*. The culture of *Phytophthora phaseoli* used by Leonian⁽³⁾ was isolated from navy beans at Morgantown, West Virginia, but a comparison of the physiological behavior of that species with that of the santol seedlings shows many essential points of agreement. Leonian's *P. phaseoli* produced an unusual abundance of oögonia on oat agar and conidia or sporangia on M/100 solution of potassium carbonate. The Philippine santol *Phytophthora* has shown the same characteristics on these media. Leonian states, however, that the resemblance between *P. infestans* and *P. phaseoli* is too striking to be overlooked and that there is no doubt that the two belong to the same species. For this reason he places *P. phaseoli* as a variety of *P. infestans*.

CONTROL MEASURES

Infected santol seedlings in the seed beds at the Singalong Experiment Station showed a very marked improvement after having been sprayed with lime-sulphur solution (1 part of lime sulphur stock solution to 40 parts water), although it was believed from previous experience that they would be a total loss on account of the severity of the infection. After five weekly applications of the spray very little sign of the disease could be detected and some of the seedlings had developed new shoots and branches. Therefore spraying with Bordeaux mixture or lime sulphur at weekly intervals during rainy weather, and at longer intervals during the drier season, is to be recommended. Spraying the plants as soon as they begin to sprout may prove to be a good preventive measure. To make the treatment more effective, however, all badly infected seedlings should be pulled up and destroyed before application of the spray, and other plants that may serve as hosts of the disease should not be planted in close proximity to santol.

Planting seeds in sterilized soil in seed flats placed on benches about a meter high from the ground is a very certain method of control. If seed beds are used the soil should be sterilized or disinfected before the seeds are sown. Close planting should be avoided as it favors the development and spread of the fungus. In watering the seedlings care should be taken not to create a very moist condition for a great length of time. The seed beds should also be high enough above the ground to prevent contamination by surface water coming from neighboring plots.

In the Philippines the disease has not been known anywhere except at the Singalong Experiment Station. It is therefore advisable, in the light of our present information, to use all means to prevent its spread to other nurseries and places. This may be accomplished by stamping out the disease as fast as it is discovered and preventing the sale or distribution of seedlings from infected seed flats and seed beds.

SUMMARY

1. A blight disease of santol seedlings caused by *Phytophthora phaseoli*, heretofore unreported, was first found in August, 1924, at the Singalong Experiment Station of the Bureau of Agriculture, Manila, P. I.

2. The fungus causes a serious disease of the seedlings in seed beds, killing up to 90 per cent of the young plants when conditions are favorable for its development.

3. The disease produces a blight of the leaves, young shoots, stems, and cotyledons of the seedlings, resulting in the final collapse and decay of the plants.

4. It is severe during warm wet weather, but not during the drier periods.

5. The morphological and physiological characteristics of the fungus agree with the descriptions of *Phytophthora phaseoli* Thaxter, which Leonian refers to *Phytophthora infestans* var. *phaseoli*.

6. The disease may be prevented by planting seeds in sterilized soil; close planting may favor it.

7. Spraying with lime-sulphur or Bordeaux mixture, proper construction of seed beds, and careful sanitation should hold the disease in check.

ACKNOWLEDGMENTS

The writer desires to acknowledge his obligations to Dr. N. G. Teodoro, acting chief of the plant-pest control division, Bu-

reau of Agriculture, and to Dr. C. J. Humphrey, mycologist and plant pathologist in charge, Bureau of Science, for their valuable suggestions in carrying out this work; to Mr. Severo Capistrano, superintendent of Singalong Experiment Station, for furnishing some of the materials; to Mr. Gaudencio M. Reyes, assistant plant pathologist, coöperative plant pathology laboratory, Bureaus of Science and Agriculture, for furnishing certain references; and to Mr. E. Cortes, photographer, Bureau of Science, for the photographic illustrations.

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3. LEONIAN, LEON H. Physiological studies on the genus *Phytophthora*. Am. Journ. Bot. 12 (1925) 7, 444-499.

ILLUSTRATIONS

[All photographs were taken by E. Cortes.]

PLATE 1

Santol seedlings showing natural infection; removed from seed beds at the Singalong Experiment Station, Manila, P. I. About 0.5 natural size.

PLATE 2

- FIG. 1. Seedlings showing typical lesions caused by natural infection on the cotyledons and stems. Natural size.
2. Seedlings artificially inoculated with the santol *Phytophthora*. About 0.25 natural size.
 3. Seedlings employed as controls. About 0.25 natural size.

PLATE 3

- FIG. 1. Typical infection on leaves, following artificial inoculation. About natural size.
2. Artificially inoculated seedlings showing characteristic aërial growth of *Phytophthora* on the cotyledons and adjacent parts. Slightly enlarged.

PLATE 4

[All drawings were made with the aid of a camera lucida by the author.]

- FIG. 1. Gnarled growth of the mycelium of the santol *Phytophthora* on potato-glucose agar +1. $\times 167$.
2. Typical mycelium of the *Phytophthora* showing protoplasmic granules, on oat agar. $\times 167$.
 3. Conidia showing the papilla, and some with the conidiophores, obtained from cultures on oat agar. $\times 167$.
 4. Cluster of conidia produced in hanging drop cultures. $\times 167$.
 5. Oöspores with the characteristic basal antheridia. $\times 167$.
 6. Direct germination of conidia by the production of a promycelium. $\times 167$.
 7. Conidia forming zoöspores. $\times 167$.
- FIGS. 8 and 9. Germinating zoöspores. $\times 167$.

TEXT FIGURES

- FIG. 1. Graph showing variation in the length of conidia.
2. Graph showing variation in width of conidia.
 3. Diagrammatic arrangement of the ratio classes.
 4. Graph showing variation in size of zoöspores.

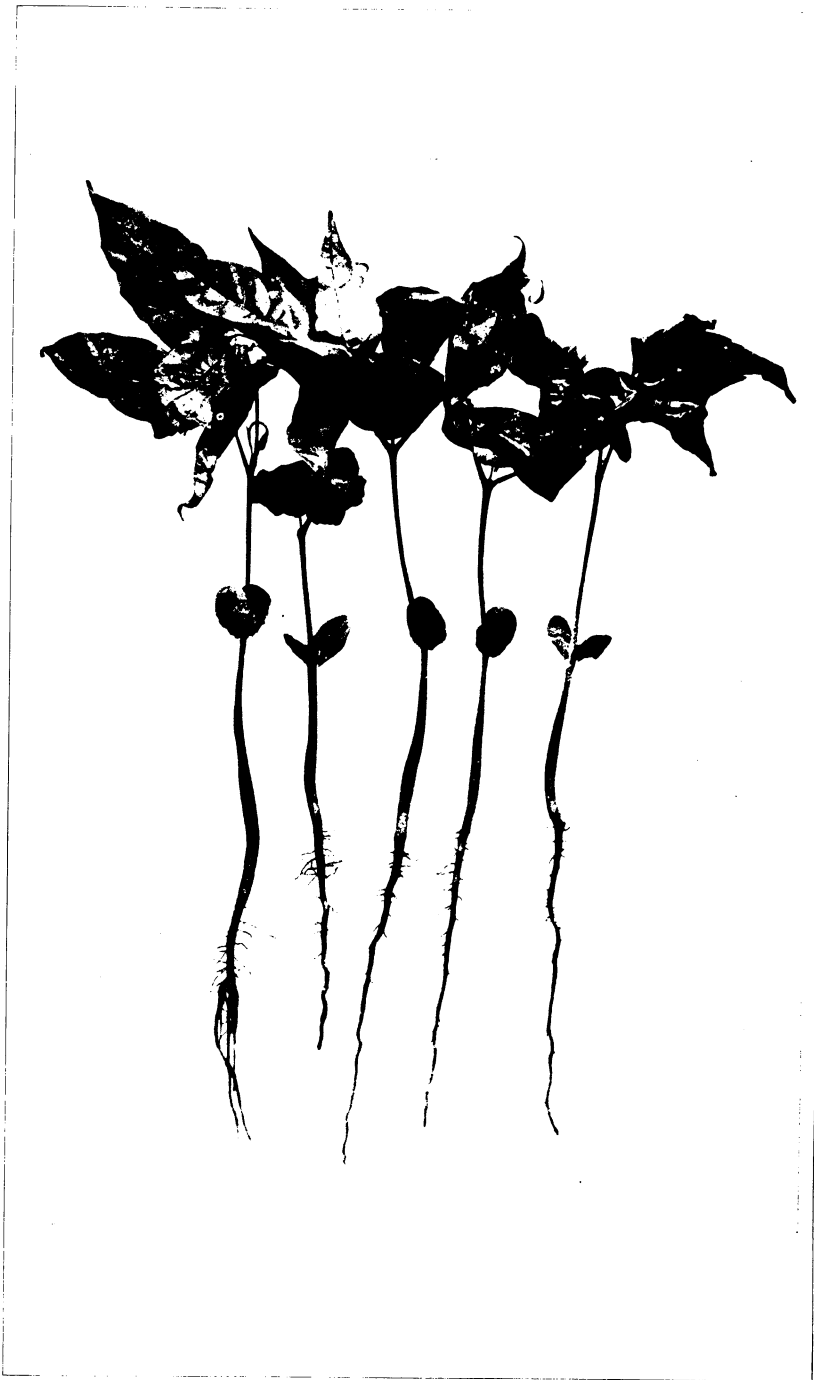


PLATE 1.

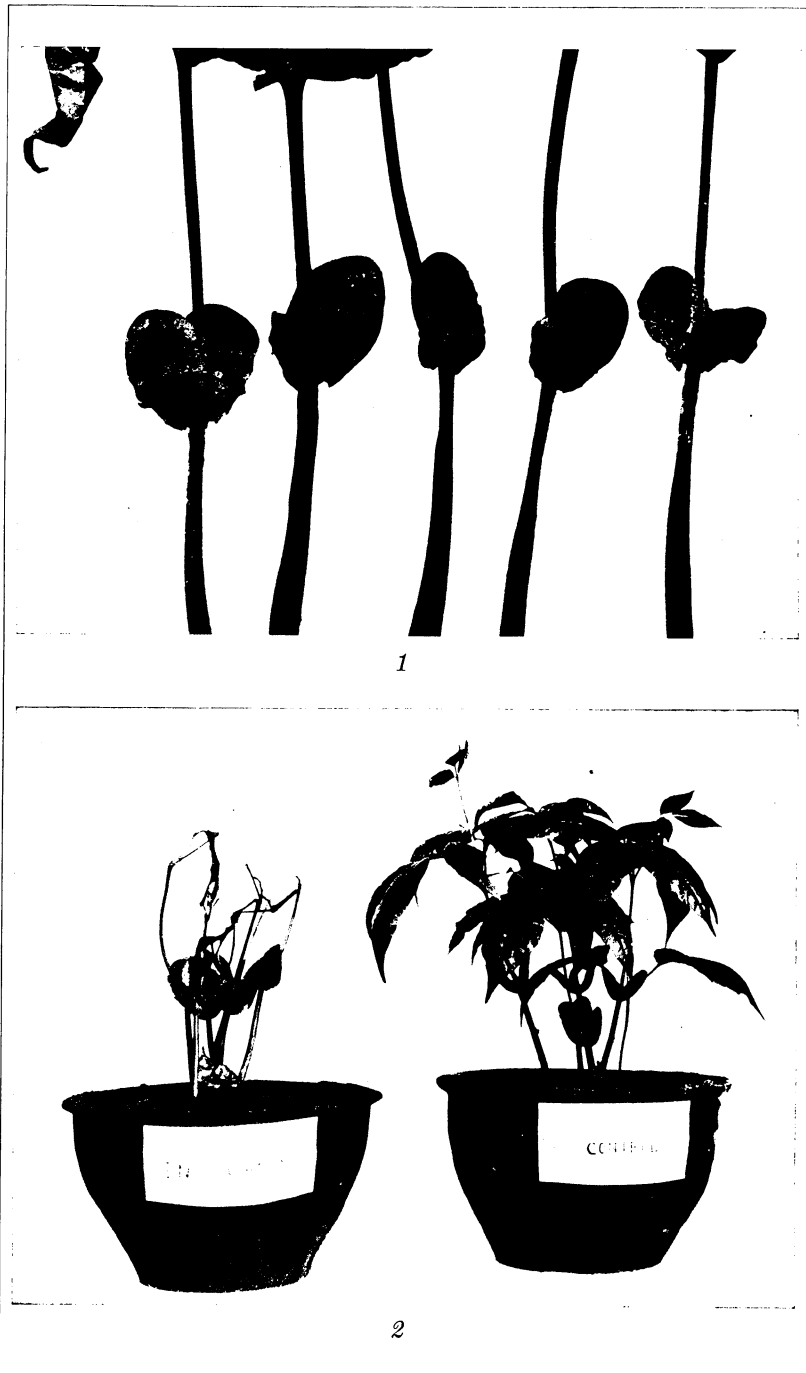


PLATE 2.



PLATE 3.

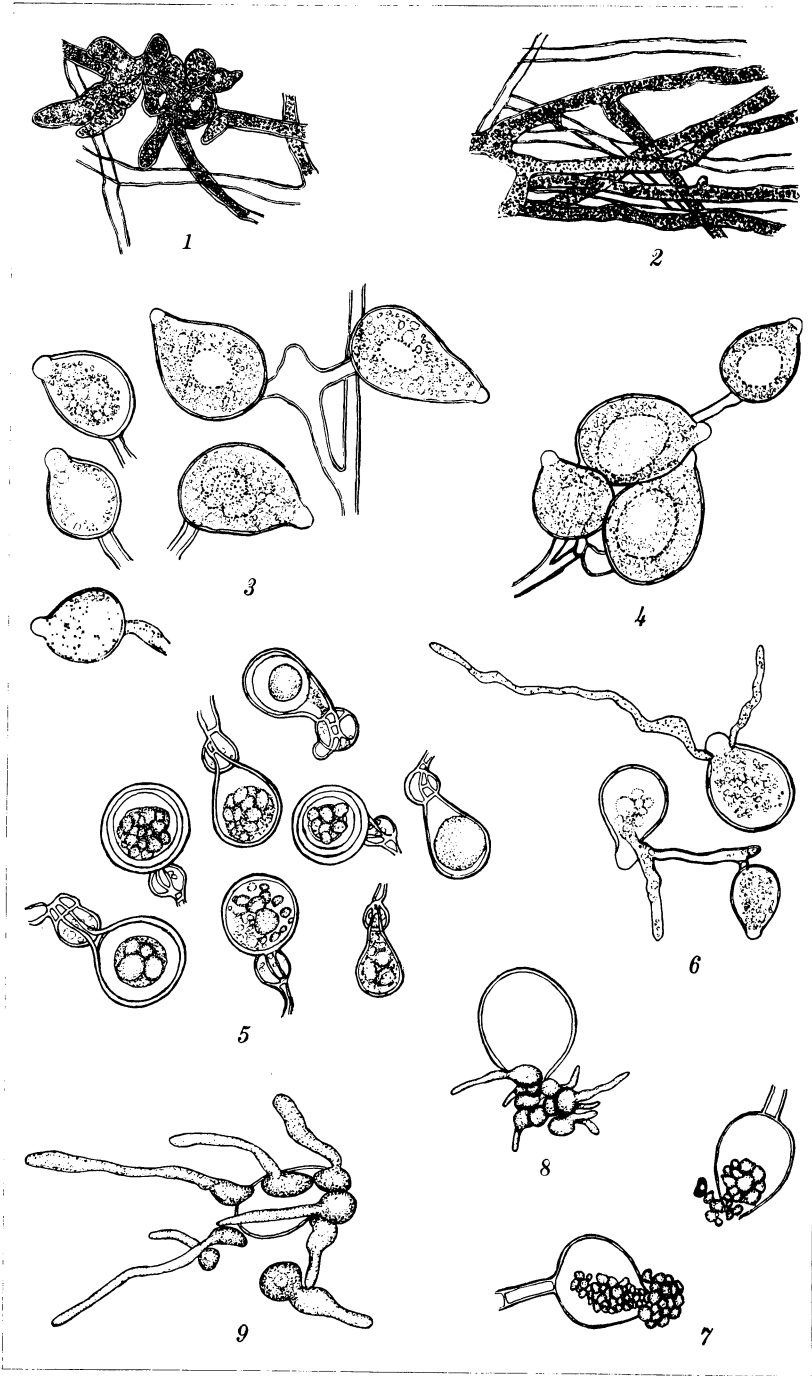


PLATE 4.

CHARLES FULLER BAKER

By E. O. ESSIG

*Professor of Entomology, College of Agriculture, University of California
Berkeley*

ONE PLATE

Charles Fuller Baker, entomologist, botanist, agronomist, collector, teacher, agricultural director and dean, died at St. Luke's Hospital in Manila, Philippine Islands, on July 21, 1927, aged fifty-five years. According to word received from D. L. Crawford, "his death was due to chronic dysentery which became acute and confined him in the hospital for two weeks before the day of his death." It is a comfort to his friends to know that during his illness he was attended by one of his own students, Capt. Leon L. Gardner, of Sternberg General Hospital in Manila. He was buried on the campus of the University of the Philippines where he spent the last nine years of his arduous life. He was born at Lansing, Michigan, March 22, 1872, the second son in a family of ten children, and was the brother of the noted author, Ray Stannard Baker, and the forester, Hugh Potter Baker.

At the Michigan Agricultural College, from which he graduated in 1892, he came under the instruction of Prof. Albert John Cook, who exerted a profound influence upon his studies in entomology and botany as well as upon many of his later activities in life. Professor Cook once told me that Baker, when a student at college, spent all of his cash for insect boxes, and by the time he graduated he had several hundred boxes of specimens, a larger and more-complete collection than was at the college at that time. As an undergraduate he assisted Professor Cook in 1891 and 1892 when he was transferred as assistant to Prof. C. P. Gillette at the Colorado Agricultural College, Fort Collins, Colorado. Here he made very extensive botanical and entomological collections and began publishing. One of his first important contributions was "A

preliminary list of the Hemiptera of Colorado"¹ in co-authorship with Professor Gillette. Most of his earlier papers dealt with the Homoptera and particularly the Cicadellidæ. It was in this publication that he described the sugar-beet leaf hopper, *Eutettix tenellus*, as *Thamnotettix*.² In 1893 he was in charge of the Colorado forestry and zoölogical exhibit of the Columbian Exposition at Chicago. The years 1897 to 1899 were spent partly in Alabama, where he acted as zoölogist in the Alabama Polytechnic Institute and entomologist in the Agricultural Experiment Station. Here he was connected with the Alabama Biological Survey. During 1898 and 1899 he was botanist on the H. H. Smith³ exploring expedition in the Santa Marta Mountains, Colombia. In 1899 to 1901 he was a teacher of biology in the Central High School at St. Louis, Missouri. Following this he studied with Prof. Vernon L. Kellogg at Stanford University, where he obtained the degree of Master of Science in 1903.

Through the efforts of Professor Cook, Baker was induced to accept the position of assistant professor of biology at Pomona College in 1903, but he remained there only one year. During this year he began the publication of *Invertebrata Pacifica*.⁴

He left California to become chief of the department of botany of the Cuban Experiment Station (Estación Agronómica), Santiago de las Vegas, Cuba, which position he held from 1904 until 1907. During this busy period also he published two very important papers on the then little-known fleas of North America.⁵

¹ Colorado Agr. Exp. Sta., Fort Collins, Colo. Bull. No. 31, Tech. Ser. No. 1 (1895) 137.

² The generic position of this insect is still questioned by systematists.

³ Celebrated entomological explorer and collector.

⁴ This serial appeared as follows: Homoptera, Vol. 1, pp. 1-12, Sept. 15, 1903; Orthoptera, pp. 13-16, Nov. 30, 1903; Diptera, pp. 17-40, Feb. 10, 1904; Hymenoptera, pp. 41-70, Aug. 26, 1904; Orthoptera, pp. 71-84, Jan. 30, 1905; Neuropteroid Insects, pp. 85-92, May 15, 1905; Hymenoptera, pp. 93-110, Aug. 20, 1905; pp. 111-132, Oct. 27, 1905; Heteroptera, pp. 133-140, Jan. 24, 1906; Hymenoptera, pp. 141-159, May 24, 1906; pp. 161-178, Feb. 28, 1907; pp. 179-198, Oct. 8, 1907. It was begun at Claremont, California, and completed (pp. 71-198) during his stay at Santiago de las Vegas, Cuba. It contained descriptions of insects which he collected personally, mostly in California and Nevada. A part of his insect collection containing types and paratypes of many of these is at Pomona College along with many exotics collected in Cuba and Brazil.

⁵ Rev. Am. Siphonaptera, Proc. U. S. Nat. Mus. 27 (1904) 1-365. Classification of N. A. Siphonaptera, *ibid.* 29 (1906) 1-121.

From Cuba he went to Brazil to assume the position as curator of the Herbarium and Botanical Garden, Museu Goeldi at Para, where he stayed one year. In Brazil he amassed very large collections of both plants and insects which were presented to Pomona College upon his return there in 1908. It was at the beginning of my junior year in college there that I came under his singular guidance. With the enthusiasm, confidence, and untiring coöperation of Professor Cook, he accomplished a remarkable piece of work at that institution. His influence upon students was very unusual, and he stimulated the most backward to produce surprising results. Many things—equipment, housing facilities, money—were needed to supply him. These were secured by Professor Cook, either directly from the college or from private individuals. Entomology at once forged ahead of all other biological sciences. Systematic and life-history work became fundamental. For the citrus-fruit growers of the region a system of orchard inspection was organized, which gave not only excellent field experiences, but also remunerative employment for advanced students, and rich returns to the growers. During his four years' stay there he inspired, trained, and sent out a fairly large group of biologists in consideration of the small size of the institution at that time.⁶

Early in 1909 he explained to Professor Cook the great need of serial publications, not only as an outlet for the work of students and specialists, but also for the benefit of all interested in the biological sciences, especially entomology and botany. Professor Cook at once agreed and undertook, single-handed, to raise sufficient money by private subscription to finance first a *Journal of Entomology*⁷ and then a *Journal of Economic Botany*.⁸ The former appeared in March, 1909, and the latter

⁶ Among this group were Charles W. Metz, J. E. Graf, D. L. Crawford, B. L. Boyden, C. F. Stahl, H. J. Ryan, F. R. Cole, A. R. Davis, John A. Prizer, R. S. Vaile, A. R. Baird, H. A. Weinland, Harry V. M. Hall, Gertrude Bacon (Mrs. H. L. Chaffee), Vinnie E. Stout (Mrs. B. P. Aborn), Blanch E. Stafford (Mrs. Charles W. Metz), Leon L. Gardner, and Sarah R. Atsatt.

⁷ Baker edited Vol 1 (1909) through No. 2, Vol. IV (1912). When Dr. W. A. Hilton succeeded as head of the department of biology and editor of the scientific journals he changed the name to *Journal of Entomology and Zoölogy*, beginning with Vol. V (1913).

⁸ The *Journal of Economic Botany* edited by Baker continued through three volumes, I (1911), II (1912), III (1913). Its discontinuance was announced in Nos. 3 and 4, Vol. III, Dec., 1914, by D. L. Crawford, then professor of botany at Pomona College.

in February, 1911. Another notable contribution was the publication of the First Annual Report of the Laguna Marine Laboratory⁹ in 1912. The Pomona College marine station at Laguna Beach was organized almost entirely through the efforts of Professors Cook and Baker, with financial assistance from a few local residents, and it is still ably conducted by Doctor Hilton.

In October, 1911, the appointment of Professor Cook as horticultural commissioner of California broke the magic ring of activities at Pomona. When he removed to Sacramento there was no one left to solicit the necessary funds to continue the work which was more than could be assumed by the college. Certain restrictions were also made to prevent outside solicitations for aid which appeared to handicap permanently the future development of the important work so gloriously started. After a year of disappointment Baker finally decided to accept the position of professor of agronomy at the University of the Philippines which was offered him by his good friend Dean E. B. Copeland, whom he succeeded in 1918. During his long stay in the Philippines he left only once and that was for a year's leave of absence in 1917-1918 to become assistant director of the Botanic Gardens at Singapore. Every ounce of vitality was poured into his work. His entomological collections received the greater part of his spare time. He maintained at his own expense a Cuban collector named Julian Hernandez, whom he carefully trained and kept with him after he left Cuba in 1907. This man spent all of his time either collecting or caring for the insects, or in the domestic duties of a bachelor's household. Botany came in for a share also, and fungi in particular were collected extensively throughout the Archipelago. Every cent of his salary that could be utilized went toward building up the collections. Concerning these he writes under date of April 27, 1925:

My outside work in entomology and mycology is the only thing that gives me any real satisfaction; that, at least, is done as it ought to be done and I can go on and develop it to the limit of personal possibilities without let or hindrance from anyone. I have pushed the number of foreign specialists engaged on our work up to one hundred ten, and keep them all busy! It thus has become one of the biggest projects of its kind

⁹ Published by the Department of Biology, Pomona College, Claremont, California, 218 pp., 130 figs.

in the world. And its ultimate permanent contribution to entomology will be very, very large. And this helps very materially to make the stay here worth while.

Failing health and disappointments many times influenced him to desire to give up his position in the Philippines and seek a place of complete change and a haven of peace and quiet in America where he could find space to house and work on this large insect collection during the remaining years of his life. To this end an attempt was made to secure for him a place at the California Academy of Sciences, but the difficulty of raising a proper endowment indefinitely delayed action until it is now too late. On August 30, 1925, he wrote: "The outside work I am carrying constantly looms larger and larger and it makes me want to stay here. But poor health will probably force me to cut loose ere long."

For several years he was considering an offer from a strong combination of all the entomological interests of the Hawaiian Islands to conduct extensive work in the western Pacific Islands—"Over Wallace's Trail." His failure to negotiate terms in California and the opportunities offered by his own student, President Crawford, of the University of Hawaii, led him finally to accept the Hawaiian offer. Accordingly, he presented his resignation to the College of Agriculture, University of the Philippines, to take effect in November, 1927. In Science¹⁰ it is stated that—

he expects to spend next year with one of the Pan-Pacific research committees on the South Sea Survey and thereafter will make headquarters at the University of Hawaii with Pres. David Crawford. Arrangements have been made to house his large collections of natural-history material at the Bishop Museum.

On June, 9, 1927, the Board of Regents of the University of the Philippines passed a resolution appointing him Professor of Tropical Agriculture and Dean Emeritus of the College of Agriculture of the University of the Philippines, and also Director Emeritus of the Experiment Station, effective December 1, 1927. His untimely death came before this much-earned public recognition was realized.

His insect collection is a remarkable achievement, amassed over a period of fourteen years of unremitting labor. From

¹⁰ Vol. 66, No. 1699, p. 77, July 22, 1927.

reports received from Baker in 1926, it contained approximately four hundred thousand specimens. On November 9, 1926, he wrote me concerning it:

The collection is undoubtedly the largest existing private collection covering the extreme western Pacific. The pinned part of it is contained in one thousand five hundred cases, all crowded full. But as much more has been placed in the hands of one hundred ten (later one hundred fifteen) specialists¹¹ and considerable portions of the latter will be returned. I believe it is one of the most important collections *basic* to either Central and South Pacific work or to Southwest Asian studies since it includes several thousand types and cotypes. Moreover, more material is constantly coming in and I have so arranged it that continued collections on a large scale will be made after I leave here. I also have a lot of fine Australian material constantly coming in. Moreover, I have taken the fullest advantage of exchange possibilities, making important exchanges with European museums and with individuals, in this way securing a vast number of species I lacked, many of these being cotypes.

According to S. A. Rohwer, information received by Dr. L. O. Howard from Baker indicates that the insect—

collection is considerably larger than it was in November, 1926, as Baker received from specialists quite a little material during the winter of 1926-27 and also continued to mount miscellaneous material which had been collected. The figures for the number of cases undoubtedly referred to the pinned part only. From information and letters, I gather that there is probably half as many specimens that are unmounted.

All the mounting, labeling, packing, and shipping to specialists was done by Baker himself at night, the entire work including the salary of the collector already referred to, cost of pins, boxes, labels, packing, and postage, was supported by his modest salary; yet, as he states, "if one lives simply and rigorously as a Trappist monk, many things may be possible." According to

¹¹ Some of the specialists who were supplied with entomological material by Baker: COLEOPTERA, Hans Gebien, R. Kleine, and A. Zimmermann, Germany; A. Boucomont, Ed. Fleutiaux, A. Grouvelle, and M. Pic, France; Jan Obenberger, Czechoslovakia; H. Krekich-Strassoldo, Austria; Chr. Aurivillius, Sweden; H. E. Andrewes and Guy A. K. Marshall, England; Edward A. Chapin, United States. ORTHOPTERA, Achille Griffini, Italy; H. H. Karny, Dutch East Indies; A. N. Caudell, United States. HOMOPTERA, Frederick Muir and D. L. Crawford, Hawaii; L. Melichar, Moravia; W. D. Funkhouser and T. D. A. Cockerell, United States. HEMIPTERA, W. L. McAtee and J. R. Malloch, United States. DIPTERA, P. Sack, Germany; W. S. Patton, Scotland; M. Bezzi, Italy; J. R. Malloch and G. F. Ferris, United States. HYMENOPTERA, E. A. Elliott, England; H. L. Viereck, Canada; T. D. A. Cockerell, United States. Baker worked chiefly in Homoptera on the Jassoidea, Fulgoridæ, and Cercopidæ, and in the Hymenoptera on the parasitic Braconidæ, during his stay in the Philippines.

his long-standing will, the main insect collection was bequeathed to the United States National Museum. The statement that small parts were also donated to the Universities of Berlin, London, Madrid, Paris, Moscow, and Vienna,¹² is probably erroneous. Crawford states that—

he [Baker] was stricken so suddenly by this accute attack of dysentery that he had no time to make any changes in his will and according to cable information received from Manila his old will still stands whereby the United States National Museum is to receive his main insect collection and the University of the Philippines is to receive his main collection of plant material.

Rohwer also states that—

the will provides that the entire collection, manuscripts and notes, should come to the National Museum. We have never been advised that there were any changes. The Museum is planning to make arrangements to have the collection transferred to Washington as soon as practical after the will is probated.

Entomology and mycology were only side issues or hobbies; his real work was the development of agriculture in the Philippines. A perusal of the files of the Philippine Journal of Science,¹³ the Philippine Agriculturist, and the Philippine Agricultural Review, on all of which he was an editorial associate, will give some idea of the results accomplished. Concerning this broader work the following editorial of the Tribune¹⁴ is pertinent:

The Baker Leadership! The University of the Philippines can ill afford to lose the services of Dean Charles F. Baker of the College of Agriculture. He has made of his college an institution of the highest standing in this country and one to which recognition abroad has been deservedly given. The Los Baños unit of the University [is] what it is because Dean Baker has put in its organization and management much of his own forceful personality and transferred to the faculty his own enthusiasm for its mission.

The work of bringing advanced methods of agricultural practices to the people on the farms has only been started. It is the work not for a decade but for a generation. In this task Dean Baker has been easily a recognized leader. It is not too much to say of him that, were he

¹² Science, No. 1701 46 (August 5, 1927) 129.

¹³ In this journal were published the results of much of the entomological work done by Baker and the large corps of specialists to whom he forwarded his material.

¹⁴ Independent Filipino Daily, Carlos P. Romulo, editor, Manila, P. I. (Nov. 6, 1926) 4.

to leave the college permanently, the Baker leadership will yet be felt through years to come. It is a measure of his success that what is often good in scientific agriculture may be traced to a Baker tradition.

Baker was a member of the American Association for the Advancement of Science, American Association of Economic Entomologists, Entomological Society of America, Washington Entomological Society, Southern California Academy of Sciences, and the Havana Academy.

Although he died comparatively young, he did the life work of ten men.

ILLUSTRATION

PLATE 1. CHARLES FULLER BAKER

The portrait on the left was taken during his stay at Pomona College, Claremont, California, in 1909; that on the right when he was at the College of Agriculture, University of the Philippines, Los Baños, P. I., in 1925.

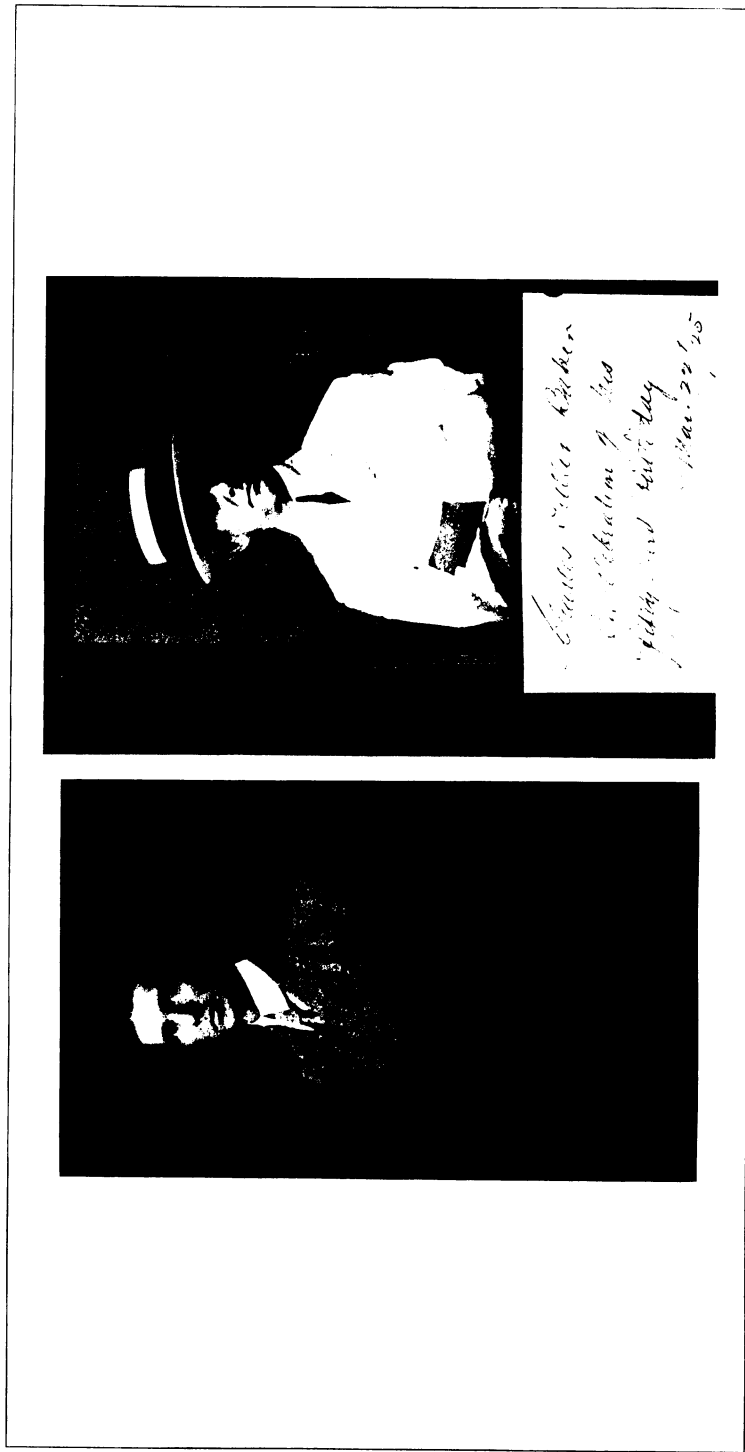


PLATE I.

NEW STEPHANIDÆ FROM BORNEO AND THE PHILIPPINE ISLANDS, IV

By E. A. ELLIOTT

Fellow of the Zoological Society of London and of the Entomological Society of London

Subfamily PARASTEPHANELLUS Enderlein

This subfamily is confined to the Indo-Australian Region, and is characterized by the discoidal cell being petiolate, and only about half as large as the cubital. I include in the following table the few species previously recorded from Borneo and the Philippines.

Key to species of the genus Parastephanellus.

FEMALES

1. 18. Hind femora tridentate.
3. 2. Terebra half as long again as body; metapleuræ smooth, hind metatarsi not white..... *P. caudatus* Elliott.
2. 3. Terebra not much longer than body.
5. 4. Vertex basally and laterally punctate; stigma very large.
P. crassistigma sp. nov.
4. 5. Vertex not punctate; stigma normal size.
7. 6. Occiput finely transstriate, frons shagreened.
P. curticollis Elliott.
6. 7. Occiput smooth.
9. 8. Frons arcuate striate, apically nearly smooth; vertex rugose, laterally smooth..... *P. rufescens* Elliott.
8. 9. Frons not arcuate striate.
13. 10. Frons rugose.
12. 11. Frons irregularly, vertex finely rugose; median segment coarsely punctate..... *P. impunctatus* Elliott.
11. 12. Frons granulate rugose, vertex transstriate; median segment superficially punctate..... *P. montanus* sp. nov.
10. 13. Frons obliquely or transversely striate.
15. 14. Frons obliquely striate, vertex transversely; metapleuræ smooth above, coarsely punctate beneath*P. monticola* Elliott.
14. 15. Frons transversely striate.
17. 16. Frons and vertex finely transstriate; metapleuræ and median segment coarsely punctate..... *P. similis* Elliott.

16. 17. Frons coarsely, vertex finely transstriate; metapleuræ rugose, median segment reticulate punctate..... *P. politus* sp. nov.
1. 18. Hind femora bidentate.
28. 19. Terebra only as long as body.
21. 20. Neck longitudinally striate..... *P. rubripictus* Elliott.
20. 21. Neck not longitudinally striate.
25. 22. Frons more or less arcuate striate.
24. 23. Frons coarsely arcuate striate, ocellar space pentagonal, petiole shorter than rest of abdomen..... *P. rugipleuræ* sp. nov.
23. 24. Frons only basally arcuate striate, ocellar space normal; petiole longer than rest of abdomen..... *P. variegatus* sp. nov.
22. 25. Frons not arcuate striate.
27. 26. Frons granulate; hind femora with two conspicuous blunt teeth behind the long sharp ones..... *P. quadridens* sp. nov.
26. 27. Frons coarsely rugose; hind femora without conspicuous smaller teeth..... *P. crassicoxæ* sp. nov.
19. 28. Terebra longer than body.
34. 29. Terebra at least half as long again as body.
31. 30. Hind femora strongly incrassate; frons subgranulate rugose, occiput apically transtriate..... *P. crassifemur* sp. nov.
30. 31. Hind femora normal.
33. 32. Frons finely and closely rugose, occiput apically transstriate; petiole longer than rest of abdomen *P. claripennis* Cameron.
32. 33. Frons finely and evenly, vertex indistinctly transstriate, occiput smooth; petiole as long as rest of abdomen.... *P. fulgens* sp. nov.
29. 34. Terebra much less than half as long again as body.
36. 35. Posterior margin of head simple; pronotum, pro-, meso-, and metapleuræ smooth..... *P. palliditarsis* Cameron.
35. 36. Posterior margin of head bordered.
38. 37. Frons arcuate striate, metapleuræ and median segment coriaceous, former closely, latter diffusely punctate.... *P. polychromus* Kieffer.
37. 38. Frons not arcuate striate; metapleuræ not coriaceous.
40. 39. Frons transstriate, metapleuræ punctate, median segment coriaceous *P. parvus* sp. nov.
39. 40. Frons subrugose striate; metapleuræ coarsely punctate, smooth apically above; median segment superficially punctate.
- P. niger* sp. nov.

MALES

6. 1. Hind femora tridentate.
3. 2. Metapleuræ smooth, separated from median segment by an impression *P. glaberrimus* sp. nov.
2. 3. Metapleuræ sculptured.
5. 4. Metapleuræ closely punctate, separated by a crenulate sulcus.
- P. politus* sp. nov.
4. 5. Metapleuræ transrugose above, otherwise coarsely punctate, separated by a carina..... *P. montanus* sp. nov.
1. 6. Hind femora bidentate.
8. 7. Basal section of radius strongly bisinuate..... *P. sinuatus* sp. nov.
7. 8. Basal section of radius straight or simply curveate.
10. 9. Vertex smooth..... *P. minutus* sp. nov.

is basally diffusely punctate laterally and apically smooth. Petiole finely transstriate, shorter than the remaining smooth, shining segments. Terebra longer than body, black. Hind coxæ coarsely transstriate, as long as the femora, which are smooth above, laterally transaciculate, tridentate, the basal tooth rather small. Tibiæ compressed to beyond middle; metatarsi nearly three times as long as the remaining joints. Radius emitted from beyond middle of the very large stigma, its distal section three times as long as the proximal.

Black; head red, vertex and occiput darker, outer orbits pale, antennæ basally and median segment red; anterior legs rufescent, middle tibiæ and tarsi basally white, hind tarsi rufescent.

Length, 9 millimeters; abdomen, 5.5; petiole, 2.5; terebra, 14. SINGAPORE (*Baker*).

The sculpture of the median segment is peculiar. It is unusual for the hind metatarsi to be entirely rufescent, when the middle ones are white basally.

PARASTEPHANELLUS CURTICOLLIS Elliott.

Parastephanellus curticollis ELLIOTT, Philip. Journ. Sci. 29 (1926) 524. Female.

PARASTEPHANELLUS RUFESCENS Elliott.

Parastephanellus rufescens ELLIOTT, Philip. Journ. Sci. 29 (1926) 523. Female.

PARASTEPHANELLUS IMPUNCTATUS Elliott.

Parastephanellus impunctatus ELLIOTT, Philip. Journ. Sci. 29 (1926) 523. Female.

PARASTEPHANELLUS MONTANUS sp. nov.

Female and male.—Frons varies from roughly transstriate to almost granulate rugose; vertex very finely transstriate; occiput smooth and shining, finely longitudinally impressed; posterior margin of head bordered; posterior tubercles small but distinct, often joined by a more or less distinct bisinuate ridge; three carinæ behind posterior ocelli. Scape about as long as cheeks; antennæ normal, third flagellar joint sometimes slightly longer than first and second together. Pronotum very short, neck laterally more or less transstriate. Mesonotum finely diffusely punctate, with three fine punctate impressions. Central lobe of scutellum smooth and shining, separated by narrow punctate sulci from the dull, finely punctate lateral lobes. Mesopleuræ dull, finely transaciculate. Metapleuræ coarsely punctate, separated by a more or less distinct crenulate sulcus from the reticulate punctate median segment. Petiole finely transstriate,

as long as the remaining segments in female, slightly shorter in male. Terebra in female as long as body or slightly longer. Hind coxæ coarsely transstriate, as long as the tridentate femora; tibiæ much longer than femora, compressed in basal two-fifths; metatarsi more than twice as long as the remaining joints in female, little longer in male. Radius emitted from distal third of stigma, its distal section three times as long as the proximal.

Black; frons red; face, base of mandibles, cheeks, temples, and two basal antennal joints testaceous or rufotestaceous; vertex and occiput black, or latter basally paler; carinæ on vertex red; a pale line under eyes. Legs often more or less rufescent, middle tibiæ and metatarsi basally hind metatarsi entirely white. Wings hyaline, stigma and nervures red-brown to black.

Length: Female, 9.5 to 13 millimeters; abdomen, 6 to 8; petiole, 3 to 4; terebra, 10 to 14; male, 9 to 11.5 millimeters; abdomen, 5 to 7; petiole, 2.5 to 3.5.

NEGROS, Cuernos Mountains. MINDANAO, Kolambugan. BORNEO, Sandakan (*Baker*).

Closely allied to my *P. monticola*, but differs in the sculpture of the frons, mesonotum, meso-, and metapleuræ.

PARASTEPHANELLUS MONTICOLA Elliott.

Parastephanellus monticola ELLIOTT, Philip. Journ. Sci. 29 (1926) 524. Female.

PARASTEPHANELLUS SIMILIS Elliott.

Parastephanellus similis ELLIOTT, Philip. Journ. Sci. 29 (1926) 522. Female.

PARASTEPHANELLUS POLITUS sp. nov.

Female.—Frons rather coarsely transstriate, two weak carinæ behind the posterior ocelli, vertex very finely transstriate, occiput and ocellar space smooth; posterior margin of head bordered; posterior tubercles well developed. Scape as long as cheeks; antennæ normal. Apical half of neck deeply impressed and laterally finely transstriate, basal half and the semiannular smooth. Mesonotum superficially punctate, apically smooth, with three punctate impressions. Scutellum smooth centrally, with marginal punctures, lateral lobes punctate. Mesopleuræ smooth, very finely punctate beneath. Metapleuræ transrugose above, otherwise coarsely punctate, separated by a carina from the reticulate punctate median segment. Petiole finely transstriate, as long as rest of abdomen, second segment basally

rugose. Terebra longer than body, black. Hind coxæ trans-striate, as long as the smooth, tridentate femora; tibiæ slightly shorter than femora and trochanters together, compressed to middle; metatarsi twice as long as the remaining joints. Radius emitted from apical third of stigma, which is rather broad, its distal section twice as long as the proximal.

Black; head red, vertex and occiput black; pronotum, base of second segment, and the hind tibiæ rufescent; anterior legs and hind tarsi rufotestaceous; middle tibiæ and metatarsi basally white; stigma and nervures red-brown. Antennæ basally testaceous.

Male.—Agrees in sculpture with the female, but the frons is more finely sculptured; hind metatarsi barely as long as rest.

Black; head and base of antennæ rufotestaceous, vertex and occiput nigrescent; pronotum, base of second segment, and hind trochanters red; anterior legs, apex of hind tibiæ, and their tarsi rufotestaceous.

Length: Female, 12 millimeters; abdomen, 8; petiole, 4; terebra, 14; male, 10 millimeters; abdomen, 6; petiole, 3.

MINDANAO, Dapitan (*Baker*.)

PARASTEPHANELLUS RUBRIPICTUS Elliott.

Parastephanellus rubripictus ELLIOT, Proc. Zool. Soc. London (1922) 759. Female and male.

PARASTEPHANELLUS RUGIPLEURÆ sp. nov.

Female.—Frons coarsely arcuate striate, ocellar space pentagonal, bounded apically by carinæ between the inconspicuous anterior tubercle and the middle pair, laterally by slighter carinæ between the middle and posterior pairs, basally by a bisinuate carina between the latter pair, the ocellar space itself being longitudinally carinate; five carinæ behind the posterior ocelli, interrupted by a longitudinal sulcus on vertex, not extending quite to base of head, remainder of vertex irregularly transcarinate and punctate, especially laterally; occiput smooth with a row of punctures; posterior margin of head strongly bordered. Scape longer than cheeks; second flagellar joint one and a half times as long as first; third shorter than first and second together. Neck rather short, laterally transcarinate, semiannular smooth, apically and laterally punctate. Mesonotum centrally smooth, with three rows of rather large punctures, apically and laterally punctate. Central lobe of scutellum smooth, with large marginal punctures, lateral lobes diffusely punctate. Propleuræ transaciculate. Mesopleuræ basally rugose punctate,

apically indistinctly sculptured. Metapleuræ coarsely rugose punctate, narrowly smooth above, separated by a strong carina from the reticulate median segment. Petiole transstriae, shorter than the remaining smooth segments. Terebra as long as body, black. Hind coxæ transstriae, as long as the smooth bidentate femora; tibiæ much longer than femora, compressed to middle; metatarsi about three times as long as the remaining joints. Radius emitted from middle of stigma, its distal section nearly three times as long as the proximal.

Black; head dark red; base of mandibles, face, and outer orbits flavescent, frons and scape light red; vertex and the carinæ nigrescent; abdomen dark rufescent; anterior legs red; hind legs dark rufescent, their tarsi paler. Stigma and nervures brownish.

Length, 11 millimeters; abdomen, 7; petiole, 3; terebra, 11.

MINDANAO, Butuan (*Baker*).

The sculpture of the head and the shape of the ocellar space are distinctive; also the black carinæ on vertex.

PARASTEPHANELLUS VARIEGATUS sp. nov.

Female and male.—Frons basally arcuately, apically transversely striate, vertex very finely transstriae, with two carinæ, occiput smooth; posterior margin of head bordered; all tubercles distinct. Scape as long as cheeks; antennæ normal. Pronotum smooth, neck of average length. Mesonotum nearly smooth, with three distinct impressions. Scutellum and mesopleuræ smooth. Metapleuræ basally smooth, apically rugose, more regularly in female than in male, separated by an indistinct carina from the diffusely and superficially punctate median segment. Petiole transstriae, slightly longer than the remaining segments in female, as long in male. Terebra in female about as long as body, rufescent. Hind coxæ transstriae, a little longer than the smooth bidentate femora; tibiæ much longer than femora, compressed in basal two-fifths; metatarsi three times as long as the remaining joints in female, little longer in male. Radius emitted from apical fourth of the centrally hyaline stigma, its distal section more than three times as long as the proximal.

Dark red to black; head red, frons and base of antennæ paler; base of mandibles and the outer orbits white, ocellar space nigrescent; pronotum, petiole, base of second segment, and hind legs light red, anterior legs paler; middle metatarsi basally, hind ones entirely white.

Length: Female, 7.5 millimeters; abdomen, 4.5; petiole, 2.5; terebra, 8; male, 5 millimeters; abdomen, 3.5; petiole, 1.25.

MINDANAO, Kolambugan. BORNEO, Sandakan (*Baker*).

PARASTEPHANELLUS QUADRIDENS sp. nov.

Female.—Frons granulate, vertex finely transstriate, occiput smooth, finely longitudinally impressed; two carinæ behind the posterior ocelli; posterior margin of head bordered. Scape as long as cheeks; antennæ normal. Pronotum smooth, neck short, deeply impressed. Mesonotum with three distinct rows of punctures, between which it is punctate, the extreme lateral angles striate. Scutellum smooth. Mesopleuræ dull, with extremely fine transaciculation. Metapleuræ and median segment reticulate punctate, separated by a strong carina. Petiole transstriate, very little shorter than the remaining smooth shining segments. Terebra as long as body, black. Hind coxæ basally rugose, apically transstriate, rather shorter than the smooth femora, which bear two long sharp teeth, and behind them two unusually large blunt teeth, in addition to the usual smaller denticulations between and beyond the large ones; tibiæ much longer than femora, compressed to beyond middle; metatarsi three times as long as the remaining joints. Radius emitted from apical third of stigma, its distal section three times as long as the proximal.

Black; head, scape, and first flagellar joint red, vertex and occiput nigrescent; carinæ on vertex bright red; a pale line under eyes; anterior legs dark red, middle metatarsi basally, hind ones entirely white. Stigma and nervures dark red-brown.

Length, 15 millimeters; abdomen, 9.5; petiole, 4.5; terebra, 15.

MINDANAO, Kolambugan (*Baker*).

Male.—Agrees with female in sculpture and color. Petiole as long as rest of abdomen; metatarsi as long as the remaining joints.

Length, 12 millimeters; abdomen, 7; petiole, 3.5.

MINDANAO, Iligan (*Baker*).

The sculpture of the head, mesopleuræ, and hind coxæ is specific, also the femoral teeth.

PARASTEPHANELLUS CRASSICOXAE sp. nov.

Female.—Frons coarsely, subtransversely rugose, vertex transstriate, with four carinæ, occiput laterally smooth, centrally very finely transstriate, with a smooth central line; posterior margin of head finely bordered; posterior tubercles low and

broad; ocellar space longitudinally striate. Scape longer than cheeks, twice as long as the first, rather stout flagellar joint, third shorter than first and second together. Neck short, transstriate, half as long as the centrally punctate semiannular, which has a few transverse striæ, basally and laterally smooth. Mesonotum centrally punctate, with three rows of punctures, laterally rugose. Central lobe of scutellum centrally smooth, laterally diffusely punctate, as are also the lateral lobes. Pro- and mesopleuræ transaciculate. Metapleuræ basally and laterally smooth, with a broad central triangular space rugose punctate; median segment reticulate punctate, laterally finely rugose, separated from the metapleuræ by a carina, which is basally fine, coarser and less regular on apical half. Petiole rather coarsely transstriate, basally more rugose, shorter than the remaining smooth segments. Terebra slightly shorter than body, black. Hind coxæ very stout, rather finely transstriate, shorter than the transaciculate, bidentate femora; tibiæ much longer than femora, compressed slightly beyond middle; metatarsi not quite three times as long as the remaining joints. Radius emitted from just beyond middle of stigma, its distal section more than twice as long as the proximal.

Black; face, mandibles basally, cheeks, and base of antennæ rufotestaceous, outer orbits whitish; anterior legs rufotestaceous, middle tibiæ and metatarsi paler, hind trochanters and compressed part of hind tibiæ rufescent, their tarsi rufotestaceous.

Length, 12 millimeters; abdomen, 7.5; petiole, 3; terebra, nearly 12.

BASILAN (*Baker*).

Especially characterized by the very short, stout hind coxæ.

PARASTEPHANELLUS CRASSIFEMUR sp. nov.

Female.—Frons subgranulately, vertex finely and evenly transstriate, occiput basally smooth, two carinæ on vertex; posterior margin of head finely bordered; all tubercles distinct. Scape as long as cheeks; antennæ normal. Pronotum smooth and shining, neck short. Mesonotum punctate with three fine impressions. Scutellum and mesopleuræ smooth. Metapleuræ mostly smooth, apical half centrally with large, superficial punctures, separated by a basally incomplete carina from the median segment, which is centrally smooth, otherwise superficially punctate. Petiole transstriate, shorter than the remaining smooth segments. Terebra much longer than body, black. Hind

coxæ irregularly transstriae, as long as the smooth, incrassate, bidentate femora; tibiæ not much longer than the femora, compressed in basal two-fifths; metatarsi three times as long as the remaining joints. Radius emitted from the apical third of stigma, its distal section four times as long as the proximal.

Black; head red, frons and base of antennæ rufotestaceous, vertex including the carinæ nigrescent, outer orbits white; anterior legs light red, hind ones rufescent, middle metatarsi rufescent, hind ones white. Stigma and nervures red-brown.

Length, 7.5 to 8 millimeters; abdomen, 4.5 to 5; petiole, 2 to 2.5; terebra, 11 to 12.

BORNEO, Sandakan. MINDANAO, Butuan (*Baker*).

PARASTEPHANELLUS CLARIPENNIS Cameron.

Parastephanellus claripennis CAMERON, Entomologist 44 (1911) 56.

PARASTEPHANELLUS FULGENS sp. nov.

Female.—Frons finely and evenly, vertex indistinctly transstriae, occiput smooth, posterior margin of head bordered; frontal tubercles well developed; one carina between posterior ocelli. Scape shorter than cheeks; first flagellar joint globose, the rest slender, second twice as long as first, third barely as long as first and second together. Pronotum, mesonotum, scutellum, and mesopleuræ smooth, mesonotum with three punctate impressions. Metapleuræ indistinctly transstriae, separated by an impression from the superficially and diffusely punctate median segment. Petiole extremely finely transstriae, as long as the remaining smooth, shining segments. Terebra much longer than body, rufescent. Hind coxæ slender, finely transstriae, apical half almost smooth, as long as the smooth, shining, bidentate femora; tibiæ much longer than femora, compressed to beyond middle; metatarsi more than twice as long as the remaining joints. Radius emitted from apical third of stigma, its distal section three times as long as the proximal.

Rufotestaceous; frons and vertex darker, outer orbits flavescent; carinæ on vertex bright red; antennæ blackish toward apex; extreme posterior margins of pronotum and scutellum nigrescent; abdomen from second segment rufescent; hind metatarsi whitish. Stigma and nervures brown-red, former basally hyaline.

Length, 7 millimeters; abdomen, 4; petiole, 2; terebra, 11.

MINDANAO, Dapitan (*Baker*).

This may be the female of my *P. leviceps* or *P. minutus*.

PARASTEPHANELLUS PALLIDITARSIS Cameron.

Parastephanellus palliditarsis CAMERON, Entomologist 44 (1911) 56.

Female and male; ELLIOTT, Philip. Journ. Sci. 29 (1926) 756.

PARASTEPHANELLUS POLYCHROMUS Kieffer.

Parastephanellus polychromus KIEFFER, Philip. Journ. Sci. § D 9

(1926) 405. Female and male.

PARASTEPHANELLUS PARVUS sp. nov.

Female.—Frons and vertex transstriae, occiput mostly, two carinae between posterior ocelli, posterior margin of head bordered; all tubercles distinct. Scape longer than cheeks; antennae normal. Pronotum smooth, neck not very short. Mesonotum smooth, with three slightly punctate impressions. Scutellum and mesopleurae smooth. Metapleurae smooth above, otherwise punctate, separated by a slight carina from the indistinctly sculptured median segment. Petiole as long as the rest of the smooth abdomen. Terebra longer than body, black. Hind coxae transstriae, as long as the bidentate femora; tibiae compressed in basal two-fifths; metatarsi more than twice as long as the remaining joints. Radius emitted from apical third of the long, narrow stigma, its distal section more than twice as long as the proximal.

Black; head red, vertex nigrescent, frons rufotestaceous, outer orbits more or less flavescent; middle metatarsi basally, hind ones entirely white; hind coxae black, legs otherwise rufescent.

Male.—The sculpture of the head, metapleurae, and median segment is less distinct. Petiole longer than rest of abdomen; hind metatarsi about as long as the remaining joints.

Head red, frons and basal half of antennae rufotestaceous; carinae on vertex and apices of the frontal tubercles light red; outer orbits white.

Length: Female, 6 to 7.5 millimeters; abdomen, 4 to 5; petiole, 2 to 2.5; terebra, 8 to 8.5; male, 5.5 to 6 millimeters; abdomen, 3.5 to 4; petiole, 1.75 to 2.

BORNEO, Sandakan (*Baker*).

PARASTEPHANELLUS NIGER sp. nov.

Female and male.—Frons varies from finely transrugose to decidedly transstriae, vertex transstriae, occiput smooth; posterior margin of head bordered; two carinae behind the posterior ocelli; all tubercles distinct. Scape as long as, or slightly longer than cheeks; antennae normal. Neck short, laterally

more or less distinctly transstriate, semiannular smooth. Mesonotum rather large, smooth, with three impressions, sometimes laterally diffusely punctate. Scutellum and mesopleuræ smooth, latter sometimes basally transaciculate. Metapleuræ coarsely punctate, with a smooth space apically above, sometimes almost smooth basally, separated from the superficially punctate median segment by a carina, on each side of which is a line of more or less distinct punctures. Petiole finely transstriate, as long as the remaining smooth segments in female, slightly longer in male. Terebra in the female as long as, or slightly longer than body, black. Hind coxæ cylindrical, transstriate, rather longer than the smooth, bidentate femora; tibiæ longer than femora, compressed in basal three-fifths; metatarsi three times as long as the remaining joints in female, as long as, or very slightly longer than in male. Radius emitted from apical third of stigma, its distal section three times as long as the proximal.

Black; head brownish red to red, frons lighter or darker red, outer orbits flavescent, ocellar space and vertex nigrescent to black, carinæ on vertex red; legs black to rufescent, middle metatarsi sometimes basally, hind ones always entirely flavescent to white. Stigma and nervures red-brown to black.

Length: Female, 9 to 13 millimeters; abdomen, 5 to 8; petiole, 2.5 to 4; terebra, 11 to 14; male, 6 to 10 millimeters; abdomen, 3.5 to 6; petiole, 2 to 3.25.

MINDANAO, Dapitan. BORNEO, Sandakan. LUZON, Mount Limay. BASILAN (*Baker*).

The differences between the specimens are due chiefly to the degree of distinctness of the sculpture, and the depth of the color. I do not consider them sufficient to justify the erection of new species.

PARASTEPHANELLUS GLABERRIMUS sp. nov.

Male.—Frons and vertex extremely finely transstriate, occiput smooth, posterior margin of head bordered; two carinæ on vertex; posterior tubercles distinct. Scape as long as cheeks; antennæ normal. Pronotum and mesonotum smooth, latter with three almost impunctate impressions, the central one indistinct. Scutellum and mesopleuræ smooth. Metapleuræ almost smooth, separated by an impression from the superficially reticulate punctate median segment. Petiole finely transstriate, as long as rest of abdomen. Hind coxæ finely transstriate, femora smooth, tridentate; tibiæ much longer than femora, compressed in basal

three-fifths; metatarsi one and a half times as long as the remaining joints. Radius emitted from apical third of stigma, its distal section nearly four times as long as the proximal.

Black; head dark red; vertex nigrescent, frons and antennæ mostly rufotestaceous, outer orbits flavescent; carinæ on vertex bright red; anterior legs rufous, tarsi paler; hind legs rufescent, their metatarsi white. Stigma and nervures red-brown.

Length, 5 millimeters; abdomen, 3; petiole, 1.5.

BORNEO, Sandakan (*Baker*).

PARASTEPHANELLUS SINUATUS sp. nov.

Male.—Frons and vertex very finely, but not very distinctly transstriate, vertex smooth; one stout carina between the posterior ocelli; posterior margin of head bordered; all tubercles distinct. Scape as long as cheeks; antennæ normal. Neck rather long, transstriate finely, semiannular smooth. Mesonotum centrally strongly punctate, lateral angles carinate, three impressions, the lateral ones apically more finely punctate. Mesopleuræ smooth above, lightly punctate beneath. Metapleuræ rugose punctate, separated from the closely punctate median segment by a strong carina, with a row of short costæ on the outer side, and a line of punctures on the inner. Petiole finely transstriate, basally rugose, longer than the remaining segments, second segment basally rugose. Hind coxæ rather coarsely transstriate, fully as long as the smooth, bidentate femora; tibiæ much longer than femora, compressed to slightly beyond middle; metatarsi about as long as the remaining joints. Radius emitted from apical fourth of the rather broad stigma, its bisinuate basal section half as long as the distal; all nervures very strong.

Black; frons and scape light red, frontal tubercles and carinæ on vertex bright red; antennæ testaceous, apically darker; second segment red; hind femora and tibiæ rufescent, anterior legs and hind tarsi rufotestaceous. Stigma and nervures red brown.

Length, 10.5 millimeters; abdomen, 6.5; petiole, 3.5.

MINDANAO, Davao (*Baker*).

Characterized especially by the very strong nervures in forewing, and the bisinuate basal section of the radius. There are quadrate depressions between the short costæ on outer side of the carina bounding the median segment. Apparently closely allied to my *P. niger*.

PARASTEPHANELLUS MINUTUS sp. nov.

Male.—Frons extremely finely and closely transstriate, vertex and occiput smooth, former sometimes with traces of apical transstriation; no distinct carinæ on vertex; posterior tubercles subobsolete; posterior margin of head bordered. Scape as long as cheeks, third flagellar joint slightly shorter than first and second together. Pronotum smooth and shining, neck half as long as the semiannular. Mesonotum short, with the usual three impressions. Scutellum and mesopleuræ smooth and shining. Metapleuræ confusedly rugose, separated by a carina from the more or less distinctly reticulate punctate median segment. Petiole as long as the remaining smooth, shining segments. Hind coxæ finely transstriate, as long as the smooth, shining, bidentate femora; tibiæ much longer than femora, compressed to beyond middle; metatarsi as long as the remaining joints. Radius emitted from apical third of stigma, its distal section three times as long as the proximal.

Dark red; head rufotestaceous, frons often testaceous, vertex sometimes darker, outer orbits flavescent; pronotum, petiole sometimes, second abdominal segment, and anterior legs rufotestaceous, hind legs lighter or darker red, their tibiæ basally and the tarsi flavescent. Stigma and nervures red-brown.

Length, 5 to 6 millimeters; abdomen, 3 to 3.5; petiole, 1.5 to 1.75.

BORNEO, Sandakan. **BASILAN** (*Baker*).

The smooth vertex and the absence of a carina are characteristic. The black ocelli are especially conspicuous.

PARASTEPHANELLUS MACULIFRONS Cameron.

Parastephanellus maculifrons CAMERON, Journ. Straits Branch. Roy. Asiat. Soc. 37 (1902) 32; ELLIOTT, Proc. Zool. Soc. London (1922) 751.

PARASTEPHANELLUS LEVICEPS sp. nov.

Male.—Frons and vertex indistinctly transstriate, occiput smooth; one carina between posterior ocelli; posterior margin of head bordered laterally only, posterior tubercle obsolete. Scape as long as cheeks, first flagellar joint globose, second twice as long as first, third scarcely as long as first and second together. Pronotum smooth and shining, neck elongate. Mesonotum smooth, with three impressions, the central one indistinct. Scutellum and mesopleuræ smooth. Metapleuræ rugose, separated by a carina from the reticulate punctate median segment. Petiole finely transstriate, longer than the remain-

ing smooth segments. Hind coxæ transstriae; femora inflated, bidentate; tibiæ little longer than femora, compressed to beyond middle; metatarsi little longer than the remaining joints. Radius emitted from apical third of the rather broad stigma, its distal section more than twice as long as the proximal.

Rufescent; head red, vertex darker, outer orbits flavescent. Pronotum and anterior legs rufotestaceous, hind legs rufescent; hind tarsi flavescent. Stigma and nervures red-brown.

Length, 8.5 millimeters; abdomen, 5.5; petiole, 3.

BASILAN (*Baker*).

This species strongly resembles my *P. minutus*. It differs in larger size, stronger sculpture of head, metapleuræ, and median segment, in the presence of a carina on vertex, and in the much longer neck.

PARASTEPHANELLUS RUGIFRONS sp. nov.

Male.—Frons transrugose, vertex coarsely transstriae, occiput smooth; two carinæ behind posterior ocelli; posterior margin of head bordered; all tubercles distinct. Scape shorter than cheeks, third flagellar joint longer than first and second together. Pronotum smooth and shining. Mesonotum with three impressions, and a row of punctures on each side of the central one, lateral angles slightly rugose. Scutellum and mesopleuræ smooth. Metapleuræ rugose punctate, separated by a basally incomplete carina from the lightly, diffusely punctate median segment. Petiole transstriae, as long as the remaining smooth, shining segments. Hind coxæ finely transstriae, their femora smooth, bidentate; tibiæ much longer than femora, compressed in basal two-thirds; metatarsi scarcely longer than the remaining joints.

Radius emitted from apical third of stigma (apices of wings broken).

Black; head dark red, outer orbits flavescent; face, frons apically, three or four basal antennal joints, and anterior legs rufotestaceous; petiole and hind legs rufescent; carinæ on vertex and second abdominal segment light red; hind tarsi whitish. Stigma and nervures brown.

Length, 7 millimeters; abdomen, 4; petiole, 2.

BORNEO, Sandakan (*Baker*).

This may possibly prove to be the male of my *P. crassifemur*.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), II

By CHARLES P. ALEXANDER
*Of Amherst, Massachusetts*¹

TWO PLATES

The species considered at this time are virtually all from the mountains of Formosa, where they were collected chiefly by Prof. Syuti Issiki. An additional Formosan species was included in the extensive collections of crane flies made in August, 1921, by Prof. Teiso Esaki. A few species are from Kiushiu and Shikoku Islands, Japan, where they were collected by Messrs. Issiki and Uyê. One interesting form that is made the type of a new genus, *Riedelomyia*, was included in the very extensive collections of the Indian Museum, Calcutta, kindly loaned to me for study by the custodians, Messrs. Chopra and Singh Pruthi. I wish to thank all of the above-mentioned students for this kind coöperation in making known the very involved tipulid fauna of the Orient. Except where stated to the contrary, the types of the novelties herein described are preserved in my collection.

In this paper and all others prepared subsequent to 1926, I have adopted the modification of the radial field of the wing suggested by myself in other papers, especially in the extended account published in 1927.² At the same time, the rearrangement of tribes and subtribes based on the apparent phylogenetic relationships of the groups is adopted, this arrangement placing the Tipulinæ and the Cylindrotominæ at the beginning of the consideration and in much closer relationship to the tribe Limoniini than was realized earlier.

¹ Contribution from the Department of Entomology, Massachusetts Agricultural College.

² Proc. Linn. Soc. New South Wales 52 (1927) 42-72, 92 figs.

TIPULINÆ

NESOPEZA CIRCE sp. nov.

General coloration brown; antennæ pale; wings gray with an extensive brown pattern, each mark bordered by a conspicuous whitish ring; a circular marginal area in cell 1st A remote from the veins; Sc_1 far before the tip of Sc_2 ; R_2 and r in perfect transverse alignment; forks of media short.

Male.—Length, about 9.5 millimeters; wing, 8.8.

Female.—Length, about 12 millimeters; wing, 11.

Rostrum and palpi dark brown. Antennæ with the scapal segments brown; flagellar segments pale yellow, vaguely darkened outwardly; flagellar segments cylindrical. Head grayish brown.

Pronotum dark brown. Mesonotal præscutum brownish testaceous with three darker brown stripes, the median one broad; scutum brownish testaceous, each lobe with two darker brown areas, the posterior one larger; scutellum brown, narrowly margined with brownish testaceous; postnotum brown, paler laterally. Propleura, anepisternum, sternopleurite, and meron dark brown, the pteropleurite and pleurotergite paler, more testaceous brown. Halteres long, pale yellow, the knobs dark brown. Legs with the fore coxæ dark brown, the remaining coxæ a little paler; trochanters pale yellow; remainder of legs broken. Wings with the ground color gray, with an extensive bright brown pattern, each marking broadly and conspicuously bordered with white to produce a remarkably beautiful pattern; cell C and outer end of cell Sc whitish. The brown areas are distributed as follows: Prearcular region except a small white spot before h ; a large postarcular cloud, including all the cells except C, sparsely variegated with white in the bases of cells M, 1st A, and 2d A; a large area at near one-third the length of cell R; origin of Rs; a conspicuous band along the cord, completely traversing the wing but almost interrupted at M; wing tip in cells R_2 , R_3 , R_4 , and M_1 , each of these with a conspicuous white inclosed area near outer end; a large circular marginal area in cell 1st A, remote from either vein, inclosing a tiny white nucleus which lies on the wing margin; tips of veins M_2 , M_3 , M_4 , and 2d A, with small brown spots, similarly encircled with white; a small area on Sc_1 ; veins brown. A single small obliterative area traverses the basal section of M_{1+2} near midlength. Venation (Plate 1, figs. 1, 1a): Sc_1 far before the tip of Sc_2 , the latter nearly twice m-cu; Rs relatively

short, angulated and weakly spurred at origin, subequal to R_3 ; R_{2+3} about one-half R_3 ; basal section of R_2 long, perpendicular, in alignment with the similarly transverse r , the distal section of R_2 entirely atrophied; distal section of R_1 without macrotrichia; R_3 gently arcuated; forks of the radial veins relatively short.

Abdominal tergites brown, variegated laterally at base with restricted yellow markings; outer segments more uniformly darkened; sternites dark, segments 3 and 4 with a conspicuous yellow crossband on the posterior half, the extreme caudal margins of the segments narrowly blackened. In the female, the pale coloration is dirty white and less evident. Ovipositor with short, stout valves, the sternal valves ending in short needlelike points.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 4,000 feet, June 2, 1927 (*S. Issiki*). Allotopotype, female.

Nesopeza circe is very distinct from all described members of the genus. The details of venation, especially the position of Sc_1 , together with the transverse alignment of r and the basal section of R_2 , are noteworthy features.

TIPULA TETRACANTHA sp. nov.

General coloration dark, the base of the abdomen yellowish; antennal flagellum bicolorous, dark, the base of each segment yellow; wings yellowish brown, the stigma brown; male hypopygium with the outer dististyle a strongly curved rod that terminates in an acute spine; inner dististyle a flattened blade, the outer margin near base bearing two acute black spines.

Male.—Length, about 13 millimeters; wing, 17; antennæ, about 4.5.

Described from an alcoholic specimen.

Frontal prolongation of the head relatively short, obscure yellow, narrowly darkened medially; nasus long and slender; palpi pale. Antennæ of moderate length; scapal segments pale; flagellar segments dark brown, the basal enlargement of each segment yellow; only twelve antennal segments, the last very small. Vertex dark, the genæ pale.

Mesonotum dark, any pruinosity normally present invisible in the alcoholic type. Pleura dark, the pteropleurite and pleurotergite paler; dorsopleural region pale. Halteres pale. Legs long and slender; fore coxæ dark, the middle coxæ dark except

basally, the posterior coxæ pale; trochanters pale yellow; femora obscure yellow, the tips narrowly but conspicuously dark brown; tibiæ obscure yellow, darker outwardly, the tips dark brown; tarsi elongated, passing into dark brown. Wings with a yellowish brown suffusion, the base and cells C and Sc more yellowish; stigma oval, brown; oblitative areas relatively conspicuous, including one in the outer end of cell R, crossing cell 1st M_2 into the extreme base of cell M_3 ; veins brown. Venation: Basal section of R_2 very reduced; distal section entire; petiole of cell M_1 short, a trifle longer than m; cell 2d A relatively narrow.

Abdomen with the basal segments yellowish, the subterminal segments passing into pale brown, the outer segments, including the hypopygium, blackened. Male hypopygium of moderate size, the tergite entirely separate from the sternite; basistyle fused with the sternite except beneath. Ninth tergite (Plate 2, fig. 13, *t*) long, narrowed outwardly, the apex terminating in two blackened subspinulose lobes that are separated from one another by a small V-shaped notch. Outer dististyle (Plate 2, fig. 13, *o*) a strongly curved, flattened, semichitinized blade that narrows to an acute black spine. Inner dististyle a broadly compressed yellow blade, the outer ventral margin armed with two conspicuous black spines (Plate 2, fig. 13, *i*). Ninth sternite with an acute notch from which hang ventrad two slender fleshy lobes that bear conspicuous yellow setæ. Eighth sternite unarmed.

Habitat.—Japan.

Holotype, male, Shikoku, July 4, 1926 (*S. Issiki*).

CYLINDROTOMINÆ

LIQMA PECTINICORNIS sp. nov.

General coloration pale yellow, the præscutum and scutum conspicuously marked with black; flagellar segments with long apical pectinations; wings nearly hyaline, the stigma pale brown.

Male.—Length, about 9 millimeters; wing, 9; antenna, about 4. Described from an alcoholic specimen.

Rostrum pale yellow; palpi pale. Antennæ with the scapal segments yellow, the flagellum a little darker; antennæ (Plate 2, fig. 22) sixteen-segmented, with thirteen branched segments, the formula being $2 + 13 + 1$; all flagellar segments except the last with a conspicuous slender branch at the extreme apex

of the segment, the longest (on flagellar segments 4 and 5) nearly as long as the segment; last branch short, scarcely one-fourth the segment; segments with conspicuous elongate verticils, including a group of four or five on the outer face of the segment before the branch; each branch terminates in two elongate setæ, that of the longest approximately two-thirds the branch; terminal segment elongate, simple. Head above brownish black, the remainder obscure yellow.

Pronotum and mesonotum pale yellow, the præscutum with three shiny black stripes, the lateral stripes crossing the suture onto the scutal lobes. Pleura yellow. Halteres pale. Legs with the coxæ and trochanters yellow; remainder of legs brownish yellow, with dark setæ, the terminal tarsal segments darker. Wings nearly hyaline, the stigma pale brown; veins dark brown. Venation: Sc_1 not reaching the margin, appearing as a long spur; Sc_2 opposite midlength of the basal section of R_{4+5} ; tip of R_1 vaguely indicated; tip of R_2 atrophied; r-m short but distinct, m-cu close to the fork of M.

Abdomen light brown, the sternites paler.

Habitat.—Formosa.

Holotype, male, Musha, altitude about 3,500 feet, October 5, 1926 (*S. Issiki*).

Liogma pectinicornis marks the most extreme tendency toward serration of the antennæ in the *Cylindrotominæ* that has yet been discovered.

LIMONIINÆ

LIMONIA FRAUDULENTA sp. nov.

Thoracic dorsum shiny black; head obscure yellow, the vertex infuscated; antennæ moniliform; dorsal pleurites black, the ventral sclerites abruptly yellow; wings with a strong brown suffusion, the stigma darker; male hypopygium with the dorsal dististyle very reduced; tips of the gonapophyses obtuse.

Male.—Length, about 5 millimeters; wing, 5.5.

Described from an alcoholic specimen.

Rostrum and palpi very short, rostrum yellow; palpi dark brown and apparently only two-segmented. Antennæ with the first scapal segment obscure yellow, the remainder of the organ dark brown; basal flagellar segments subglobular, a little broader than long, distinctly separated so as to appear moniliform; outer segments passing into oval; terminal segment elongate, pointed at apex. Head pale yellow, the vertex infuscated, paling into yellow behind.

Pronotum pale yellow in front, shiny black behind. Mesonotum entirely shiny black; pleura black dorsally, abruptly pale yellow ventrally, the latter color including the sternopleurite and meron. Halteres dusky, the knobs obscure yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips infuscated; tibiæ brownish yellow, the tips narrowly infuscated, tarsi obscure brownish yellow, the terminal segment blackened. Wings with a strong brownish suffusion, the oval stigma darker brown; veins dark brown. Venation (Plate 1, fig. 2): Sc long, Sc₁ ending just beyond midlength of Rs, Sc₂ at its tip; Rs about twice the basal deflection of R₄₊₅; distal section of R₁ and basal section of R₂ in approximate transverse alignment; cell 1st M₂ relatively small, shorter than the veins beyond it; m-cu subequal to the distal section of Cu₁, placed shortly before the fork of M.

Abdominal tergites dark brown; sternites similar, the caudal margins of the intermediate segments narrowly yellowish; subterminal segment brownish yellow; hypopygium dark. Male hypopygium (Plate 2, fig. 14) with the ninth tergite low, the caudal margin gently emarginate. Basistyle relatively slender, the mesal lobe very large. Ventral dististyle smaller than the basistyle, fleshy, the rostral prolongation long and conspicuous, near its base with a small tubercle that bears two closely approximated pale spines. Dorsal dististyle reduced to a very small, slender rod. Ædeagus broad, with very broad subtending lateral wings. Gonapophyses stout, flattened, their tips obtuse.

Habitat.—Formosa.

Holotype, male, west side of Mount Daibu, altitude 3,000 to 5,000 feet, mid-March, 1927 (*S. Issiki*).

In its polished black thorax, *Limonia fraudulenta* bears a conspicuous superficial resemblance to species of *Dicranomyia* of the *morio* group.

LIMONIA REMISSA sp. nov.

General coloration pale ochereous, anterior vertex silvery; mesonotal præscutum with three darker brown stripes; a dorsal longitudinal brown stripe on the thoracic pleura; wings pale brownish yellow with an extensive pattern of brown spots and seams; Sc long.

Male.—Length, about 7 millimeters; wing, 6.8.

Described from an alcoholic specimen.

Rostrum and palpi black. Antennæ with the first scapal segment black, the second a little paler; flagellum pale brown; flagellar segments oval, passing into elongate-oval; terminal segment elongate, nearly twice the penultimate. Anterior vertex silvery gray, with a small median tubercle; head behind blackened, the median area more silvery.

Pronotum pale ochereous above, dark brown laterally. Mesonotum pale ochereous, the præscutum with three darker brown stripes; scutal lobes and scutellum dark brown, the median area of the former paler; postnotum dark. Pleura yellow with a broad dark brown longitudinal stripe that extends from the cervical sclerites across the dorsal pleurites to the postnotum, including the pleurotergite; sternopleurite a little infuscated ventrally. Halteres relatively elongate, pale, the knobs infuscated. Legs with the coxæ obscure yellow; trochanters brownish yellow; femora brownish yellow, clearer yellow basally, the tips narrowly darker brown; tibiæ and tarsi darker brown, especially the distal segments of the latter. Wings with a pale brownish yellow suffusion, darker in the costal region and base of cell R; an extensive rich brown pattern, consisting of large spots and seams that are diffuse and poorly delimited, including the following: Base of cells R and M; a large area at origin of Rs, not reaching M; a smaller cloud at end of Sc, extending from the costa posteriorly almost across cell 1st R₁; the stigmal spot completely fusing with a broad seam along the cord and with conspicuous dusky seams that fill cells 2d R₁ and R₃ excepting a large pale spot beyond the stigma; a broad seam on the outer end of cell 1st M₂; large diffuse spots at ends of veins M₃, M₄, Cu₁, and the anal veins, becoming larger toward the wing base; veins pale brown, paler in the ground areas. Venation: Sc long, Sc₁ ending about opposite three-fifths the long Rs, Sc₂ not far from its tip; Rs angulated and short-spurred at origin; tip of R₁ in approximate alignment with R₂; cell 1st M₂ elongate, nearly as long as vein M₁₊₂ beyond it; m-cu a little shorter than the distal section of Cu₁, placed shortly before the fork of M.

Abdominal tergites dark brown, the incisures restrictedly pale; sternites 1 to 4 with the basal third or more conspicuously pale yellow. Male hypopygium (Plate 2, fig. 15) with the basistyle relatively large, the mesal lobe large, obtuse. Ventral dististyle smaller than the basistyle, pale, the apex bilobed, the outer or lateral portion setiferous, the inner portion larger,

produced mesally into a flattened beaklike rostrum; on the side of this inner lobule an oval area that is densely set with conspicuous tawny setæ; outer face of the rostrum with a similar fringe of setæ. Dorsal dististyle a relatively slender, curved chitinized rod, the tip acute, decurved. Gonapophyses very broad and flattened, the mesal apical angle produced caudad into a nearly straight slender lobe. *Ædeagus* broad.

Habitat.—Formosa.

Holotype, male, Musha, altitude about 3,500 feet, October 5, 1926 (*S. Issiki*).

LIMONIA EBRIOLA sp. nov.

General coloration dark brown; antennæ dark brown throughout; halteres and legs dark brown; wings with a strong brown suffusion, the stigma and seams on the transverse veins darker brown; male hypopygium with the spines of the rostral prolongation of the ventral dististyle long, slender, widely separated.

Male.—Length, about 6.2 millimeters; wing, 8.

Rostrum and palpi dark brown. Antennæ dark brown; flagellar segments oval, becoming more elongate-oval outwardly, with long conspicuous verticils. Head dark brown.

Pronotum dark brown. Mesonotum brown, the præscutal stripes somewhat darker brown, the surface sparsely yellowish pollinose, brighter sublaterally. Pleura dark brown, the surface pruinose, leaving narrow longitudinal stripes of the ground color on the sternopleurite and across the ventral anepisternum and pteropleurite; dorsopleural region broadly paler brown. Halteres dark brown, the base of the stem yellow. Legs with the fore coxæ brown, remaining coxæ yellow; trochanter yellow; remainder of legs dark brown, the femoral bases a little brighter. Wings with a strong brown suffusion, the oval stigma darker brown; narrow but conspicuous brown seams at origin of *Rs*, along the cord and outer end of cell 1st *M*₂; veins dark brown. Venation (Plate 1, fig. 3): *Sc* relatively short, *Sc*₁ ending about opposite one-third the length of *Rs*, *Sc*₂ not far from its tip. *Rs* weakly angulated near extreme origin; tip of *R*₁ distinct but pale; *r* and basal section of *R*₂ meeting angularly; cell 1st *M*₂ relatively short, rectangular, shorter than the veins issuing from it; *m-cu* close to the fork of *M*.

Abdominal tergites brownish black; basal sternites yellowish brown, the caudal margins brighter; subterminal segments brighter; hypopygium dark. Male hypopygium (Plate 2, fig. 16) with the caudal margin of the ninth tergite produced into

two obtuse lobes that are conspicuously setiferous. Basistyle of moderate size, its mesal lobe large. Dorsal dististyle a strongly curved sickle-shaped hook. Ventral dististyle large and fleshly, with numerous microscopic setulæ and more sparse long setæ; rostral prolongation stout, the two slender spines widely separated; outer spine arising from a short enlarged base, gently curved; inner spine a little shorter and more nearly straight; space between the spines with sparse erect setulæ. Gonapophyses pale, broadly expanded, the mesal apical angle produced into a long, slender, gently curved rod.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 6,000 feet, June 3, 1927 (*S. Issiki*).

DICRANOMYIA CINGULIFERA sp. nov.

General coloration dark brown; rostrum relatively elongate; antennæ dark brown, the second segment pale yellow; pleura silvery gray with two longitudinal dark brown stripes; halteres yellow, the knobs dark brown; femora obscure yellow with a dark brown subterminal ring; wings whitish subhyaline, heavily variegated with dark brown, especially beyond the cord; Sc elongate; abdomen brownish black, the segments ringed caudally with silvery gray.

Female.—Length, 5.5 to 6 millimeters; wing, 5 to 5.8.

Rostrum relatively elongate, approximately as long as, or a little longer than, the remainder of the head, black; palpi black. Antennæ with the first scapal segment dark brown; second segment pale yellow; flagellum dark brown, the segments short-oval, the outer segments smaller and more nearly globular; terminal segment longer, the apex pointed. Head brownish gray.

Pronotum brown, with a yellowish pollen. Mesonotal præscutum yellowish gray, clearer gray laterally, with four narrow dark brown stripes, the intermediate stripes narrower, separated from one another by a slightly narrower line of the ground color; a circular brown spot near the lateral margin behind the pseudosutural foveæ; scutum yellowish gray, the centers of the lobes darker; scutellum and postnotum brownish gray, the latter darker behind. Pleura silvery gray, variegated with two longitudinal dark brown stripes, the narrow dorsal stripe crossing the ventral propleura and anepisternum, the broader ventral stripe including the ventral portion of the sternopleurite. Hal-

teres pale yellow, the knobs dark brown. Legs with the coxæ brown, paler apically, the fore coxæ more reddish brown; trochanters yellowish testaceous; femora obscure yellow with a relatively broad dark brown subterminal ring, the extreme tip narrowly pale yellow; tibiæ and basitarsi brownish yellow, the tips narrowly infuscated; remainder of tarsi darker brown. Wings whitish subhyaline, the base and costal region a trifle more yellowish; a conspicuous dark brown pattern that is much heavier beyond the cord; seams on h ; Sc_2 ; a large spot beyond arculus; an elongate rectangular area at origin of Rs , extending from costa almost to M , including the tip of Sc_1 ; stigma short-oval to subrectangular, connected with a narrow seam along the cord; outer ends of cells $2d R_1$ and R_3 heavily infuscated; a narrow seam on outer end of cell 1st M_2 ; marginal brown spots on veins M_{1+2} , M_3 , and M_4 ; smaller similar spots on Cu_1 and 1st A ; a large marginal spot on vein $2d A$; veins pale, darker in the infuscated areas. Venation: Sc_1 ending just beyond the origin of Rs , Sc_2 far from its tip, at near mid-distance between arculus and origin of Rs ; Rs weakly angulated at origin; tip of R_1 and base of R_2 in approximate transverse alignment; cell 1st M_2 elongate-rectangular, subequal to vein M_{1+2} beyond it; elements closing the cell very faint; $m-cu$ close to the fork of M , a little shorter than the distal section of Cu_1 .

Abdomen brownish black, the segments broadly and conspicuously ringed caudally with silvery gray; base of genital segment blackened; valves of ovipositor relatively small, nearly straight, reddish horn color.

Habitat.—Formosa.

Holotype, female, Mount Rantaizan, altitude 7,000 feet, June 2, 1927 (*S. Issiki*). Paratopotypes, two females, with the type; one female, 6,000 feet, June 3, 1927.

DICRANOMYIA FRIVOLA sp. nov.

Female.—Length, about 6.5 millimeters; wing, 7.6, its greatest width, 2.2.

Belongs to the *pulchripennis* group, most closely allied to *D. shirakii* Alexander, from which it differs especially in the broader wings with the white ground color more extensive.

Antennal flagellum weakly bicolorous, the ground color of the basal segments obscure yellow, the outer segments brownish black with the bases narrowly pale. Femoral tips, tibial bases, and tibial tips broadly and conspicuously blackened. Wings

broad, as shown by the above measurements; whitish, the extreme base a little more yellowish; costal pattern as in *shirakii*, with five extensive costal blotches, the first three of which are entire and more or less T-shaped, the caudal extension of each blotch in cell R being much narrower than the dilated costal portion; the white ground color separating these dark costal areas wider than in *shirakii*; cell R_3 and the cephalic portion of R_5 with clearly defined, relatively small, dark brown spots that do not tend to become confluent; cells $2d\ M_2$, M_3 , and M_4 with the ground color more extensive, the dark pattern more contrasted.

The cells of the wing are wider than in *shirakii* due to the greater breadth of the wing; cell $1st\ M_2$ relatively short, its lower face shorter than vein M_4 beyond it; m-cu more than one-half its length before the fork of M.

Habitat.—Formosa.

Holotype, female, Mount Rantaizan, altitude 7,000 feet, June 3, 1927 (*S. Issiki*).

DICRANOMYIA NESOMORIO sp. nov.

Belongs to the *morio* group; male hypopygium with the caudal margin of the ninth tergite bearing two widely separated slender lobes; mesal lobe of basistyle long and slender; dorsal dististyle bifid at apex.

Male.—Length, about 5 to 5.5 millimeters; wing, 6 to 6.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, the outer segments becoming more elongate-oval. Head black, the anterior vertex silvery, the posterior vertex narrowly grayish.

Pronotum black, sparsely pruinose. Mesonotum shiny black, especially the præscutum; median region of scutum, scutellum, and postnotum more pruinose. Pleura black, heavily silvery pruinose. Halteres elongate, dark brown, the base of the stem narrowly pale. Legs with the fore and middle coxæ brownish black, pruinose, paler apically, the posterior coxæ uniformly pale; trochanters reddish yellow; remainder of the legs black, the femoral bases restrictedly obscure yellow. Wings with a strong brownish tinge, the oval stigma darker brown; very vague and narrow dusky seams on the cord; veins darker brown. Venation: Sc_1 ending just beyond the origin of the long Rs ; distal section of R_1 weakly preserved, lying a little basad of the equally pale basal section of R_2 , r thus being preserved and

provided with two or three macrotrichiae; cell 1st M_2 closed, a little shorter than vein M_{1+2} beyond it; m-cu subequal to the distal section of Cu_1 , lying shortly before the fork of M .

Abdomen black, the caudal margins of the tergites broadly brown; sternites black, the caudal margins of segments 2 to 5 broadly yellowish brown; hypopygium dark. Male hypopygium (Plate 2, fig. 17) with the ninth tergite having the caudal margin terminating in two long slender lobes, widely separated by a broad U-shaped notch, the tips of the lobes with conspicuous setae. Basistyle relatively small, dark, bearing a small subterminal tubercle on dorsal mesal margin; mesal lobe very long and slender, narrowed gradually to the subacute apex, paler than the remainder of the style. Ventral dististyle larger than the basistyle, fleshly, the rostral prolongation bearing a single stout pale spine near base. Dorsal dististyle gently curved, the tip bifid, the outer spine obtuse, the inner spine acute. Gonapophyses small.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 6,000 feet, June 2, 1927 (*S. Issiki*). Paratopotype, male; paratype, male, Rengechi, altitude 1,500 to 2,000 feet, end of March, 1927 (*S. Issiki*).

Genus *PROTOHELIUS* novum

Rostrum short, not produced; palpi four-segmented, conspicuous, the terminal segment nearly twice the penultimate, slender. Antennae sixteen-segmented; flagellar segments long-cylindrical, gradually decreasing in length and diameter outwardly; terminal segment about one-half the penultimate; verticils relatively inconspicuous, not longer than the segments. Anterior vertex relatively narrow, about one-third wider than the diameter of the first scapal segment, subequal in both sexes; eyes relatively large and protuberant, with delicate ommatidia. Pronotum relatively massive. Legs comparatively stout; no tibial spurs; claws simple; empodia distinct. Wings (Plate 1, figs. 5, 5a) broad; Sc long, Sc_1 ending beyond midlength of R_{8+z} , Sc_2 about opposite the fork of Rs ; tip of R_1 preserved; r short; basal section of R_2 preserved, perpendicular or even slightly recurrent at origin, the distal section preserved, without macrotrichiae; tips of Sc_1 , R_1 , and R_2 all relatively close together at wing margin; R_{2+3} a little longer than the basal section of R_{4+5} ; cell 1st M_2 closed, irregularly pentagonal; m-cu at the

fork of M, subequal to the distal section of Cu_1 ; cell 2d A wide; h very faint, oblique. Male hypopygium (Plate 2, fig. 18) with the basistyle short and stout. Outer dististyle broad-based, narrowed into an elongate blackened tip, on the mesal face near midlength with a short blunt blackened lobe. Inner dististyle of almost the same length and form as the outer, terminating in a long pale outer lobe and bearing a shorter lateral fleshy lobe on mesal face near base. Phallosome modified into a cylindrical structure. Ovipositor with the valves long and straight, the tips of the tergal valves gently upcurved.

Genotype, *Protohelius issikii* sp. nov. (Oriental Region.)

Protohelius is of extreme importance in that it indicates the manner in which the radial field in the more-aberrant subtribes of the Limoniini (such as the Heliaria, Dicranoptycharia, Tonnoiromyaria, and Aphilimnobararia) may have been derived. From a study of this genus, it appears that it is usually the free tip of R_1 that atrophies, leaving the distal end of R_2 persistent.

PROTOHELIUS ISSIKII sp. nov.

General coloration yellow, the thoracic dorsum extensively shiny black; wings broad, grayish brown, the stigma darker; abdomen dark brown, the basal sternites yellow.

Male.—Length, about 8.5 millimeters; wing, about 10.

Female.—Length, about 10 to 10.5 millimeters; wing, 10.5 × 3.2.

Described from alcoholic specimens.

Rostrum pale, the palpi dark brown, the terminal segment paler apically. Antennæ with the scapal segments brownish yellow, the flagellum dark brown. Head dark brown, paler beneath.

Pronotum yellow. Mesonotum almost covered by a shiny black dorsal shield, the lateral margins of the præscutum broadly yellow; central portion of the transverse suture pale; lateral margins of the scutal lobes and the parascutella pale yellow. Pleura pale yellow, including the pleurotergite, the ventral sternopleurite darkened. Halteres pale, the knobs weakly darkened. Legs relatively stout; coxæ and trochanters yellow; femora yellow basally, passing into dark brown; remainder of legs yellowish brown, the terminal tarsal segments darker brown; tarsal segments 3 and 4 each with a stout spinous bristle near apex. Wings broad, with a grayish brown suffusion,

the prearcular region more yellowish; cells Sc and Cu₁ darker; stigma brown; veins darker than the ground color. Venation (Plate 1, figs. 5, 5a) as discussed under the genus.

Abdomen dark brown, the basal sternites yellow, the intermediate sternites with the lateral margins pale; hypopygium pale. Female with the genital segment horn yellow, the valves darker.

Habitat.—Formosa.

Holotype, male, Rengechi, altitude 1,500 to 2,000 feet, end of March, 1927 (*S. Issiki*). Allotopotype, female. Paratopotypes, one male, one female.

This peculiarly interesting type of crane fly is named in honor of my friend Prof. Syuti Issiki, to whom I am greatly indebted for coöperation in studying the crane flies of Japan and Formosa.

HELIUS RUFITHORAX sp. nov.

Rostrum elongate; head dark gray; mesonotum and pleura shiny ferruginous, without markings; wings grayish subhyaline, the base and costal region more yellowish; abdominal tergites with the distal segments uniformly blackened, this including the hypopygium.

Male.—Length (excluding rostrum), about 7.5 millimeters; wing, 8.6; rostrum, 2.8.

Female.—Length (excluding rostrum), about 8 millimeters; wing, 9 to 9.5; rostrum, 2.8.

Rostrum elongate, approximately equal to the combined head and thorax, black throughout; palpi black. Antennæ brownish black, the second scapal segment a little paler. Head dark gray, the anterior vertex narrow.

Mesonotum shiny ferruginous, without markings. Pleura shiny yellowish ferruginous. Halteres pale, the knobs infuscated. Legs with the coxæ concolorous with the pleura; trochanters a little more yellowish testaceous; femora obscure yellow, the tips narrowly blackened; tibiæ obscure brownish yellow, the tips very narrowly darkened; tarsi brown, the terminal two segments darker. Wings grayish yellow subhyaline, the base and cells C and Sc clearer yellow; stigma oval, dark brown; wing tip in cells 2d R₁ and R₃ narrowly darkened; a narrow vague seam on the anterior cord; a conspicuous dusky seam along vein Cu; veins brown, brighter in the basal and costal regions. Venation: Sc₁ ending opposite the fork of Rs, Sc₂

at its tip; r-m distinct; cell 1st M_2 relatively broad, subrectangular; m-cu shortly beyond the fork of M.

Abdomen with the basal tergites brownish yellow, the caudal margins of the segments darkened; outer four or five segments, including the hypopygium, uniformly blackened. Female with the tergites uniformly dark brown, the basal sternites obscure brownish yellow.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 7,000 feet, June 4, 1927 (*S. Issiki*). Allotopotype, female, 6,000 feet, June 3, 1927. Paratopotype, female, with the type.

Helius rufithorax is allied to the smaller *H. tenuirostris* Alexander, differing in the longer rostrum, the uniform thorax, the unvariegated abdominal segments, black hypopygium, and other characters.

EURHAMPHIDIA INELEGANS sp. nov.

General coloration pale brown, the mesonotum darker; head dark; legs with the femoral tips yellow; tibial bases very narrowly pale; tips of the tibiæ and most of the tarsi white; wings subhyaline, the stigma pale brown; Sc relatively long, veins R_3 and R_{4+5} strongly divergent.

Female.—Length, about 6 millimeters; wing, 5.3.

Described from an alcoholic specimen.

Rostrum obscure yellow, the apex darker; palpi dark brown. Antennæ with the first scapal segment yellow, the second dark brown; flagellum pale brown, the outer segments broken. Head dark brown.

Pronotum pale brown, yellowish laterally. Mesonotum pale brown, the præscutum with a broad median and narrower lateral stripes of a darker color; remainder of mesonotum chiefly dark brown. Pleura obscure yellow, sparsely variegated with brown on the sternopleurite and pleurotergite. Halteres pale brown, the base of the stem brighter. Legs with the coxæ obscure yellow, the outer faces more or less infuscated; trochanters obscure brownish yellow; femora pale brown, the tips paling into yellow; tibiæ darker brown, the extreme bases vaguely paler, the tips whitened; tarsi pure white, excepting the terminal two segments which are infuscated. Wings (Plate 1, fig. 4) subhyaline; cells C and Sc a trifle more yellowish; stigma oval, relatively small, pale brown; veins brown. Wings relatively short and broad, more so than in *E. abnormalis*

(Brunetti), the cells correspondingly widened, the prearcular cells shortened. Vein M_4 without macrotrichiae. Venation: Sc relatively long, Sc_1 ending about opposite one-fourth the second section of Rs , Sc_2 longer, ending about opposite one-third the same; second section of Rs approximately three-fourths the first; veins R_3 and R_{4+5} strongly divergent and relatively short, cell R_3 at margin wide; $m-cu$ at near two-thirds the length of cell 1st M_2 .

Abdominal tergites pale brown, the sternites obscure yellow. Ovipositor with the valves strongly infuscated; tergal valves straight, the tips a little upcurved.

Habitat.—Formosa.

Holotype, female, Musha, altitude about 3,500 feet, October 5, 1926 (*S. Issiki*).

Eurhamphidia inelegans has the pattern of the femora and bases of the tibiae much more obscured and ill-defined than either *E. niveitarsis* (Skuse) or *E. abnormalis* (Brunetti).

DICRANOPTYCHA FORMOSENSIS sp. nov.

General coloration brownish gray, the thoracic pleura pale with the anepisternum darker; legs yellow, the tips of the segments very narrowly and inconspicuously blackened; wings grayish yellow, the costal region clearer yellow; costal fringe short; male hypopygium with the outer dististyle densely set with short setae, terminating in an acute black spine; gonapophyses elongate, terminating in a unilateral brush of long setae.

Male.—Length, about 8 millimeters; wing, 9.2.

Female.—Length, about 9.5 to 10 millimeters; wing, 10.2 to 10.5.

Rostrum reddish brown, the palpi dark brown. Antennae reddish brown, the outer segments darker, feebly bicolorous, the joints being paler than the central portion of each segment. Head brownish gray.

Mesonotal praescutum brownish gray, the median area of the praescutum somewhat brighter brown; pseudosutural foveae black; scutum brownish gray; scutellum a little more reddish brown, pruinose; postnotum more heavily pruinose. Pleura pale, the anepisternum darker, the surface sparsely pruinose, in the paratype more heavily so. Halteres pale yellow, the knobs scarcely darker. Legs with the coxae pale, very sparsely pruinose; trochanters yellow; remainder of legs yellow, the extreme tips of the femora on the outer face, the similarly narrow tips of the tibiae and basitarsi, and the terminal tarsal segments

brownish black. Wings with a grayish yellow suffusion, the prearcular and costal regions clearer yellow; veins brownish yellow; costal fringe (male) short. Venation: Rs from one-third to one-half longer than cell 1st M_2 ; m-cu at near midlength of cell 1st M_2 .

Abdomen with the basal tergite dark brown; remaining segments obscure yellow, dark brown laterally; a subterminal dark brown ring; hypopygium yellow; sternites similar, the basal segments obscure yellow. Male hypopygium (Plate 2, fig. 19) with the outer dististyle a compressed elongate blade, densely set with relatively short setæ, the apex of the style narrowed into a long curved black spine. Inner dististyle longer, appearing as a flattened, parallel-sided elongate rod, the tip obtuse, the inner face set with erect spinous setæ. Gonapophyses very conspicuous, appearing as long taillike rods that are provided just before their tips with very long spinous setæ, arranged to form a subapical unilateral brush.

Habitat.—Formosa.

Holotype, male, Ranrun, altitude 1,000 feet, June 2, 1927 (S. Issiki). Allotopotype, female. Paratopotype, female.

DICRANOPTYCHA GENICULATA sp. nov.

General coloration brownish black; ventral pleurites paler; legs yellow, the tips of the femora broadly brownish black; bases and tips of the tibiæ similarly blackened; wings brownish, the bases and costal region more yellowish; costal fringe short; abdomen brownish black, the hypopygium obscure yellow; male hypopygium with outer dististyle having the outer surface spinous; gonapophyses elongate, the surface smooth.

Male.—Length, about 10 millimeters; wing, 9 to 9.5.

Female.—Length, about 12 millimeters; wing, 10.

Described from alcoholic specimens.

Rostrum brownish testaceous, the palpi dark brown. Antennæ dark brown throughout, relatively long in both sexes; first flagellar segment approximately twice the length of the second; succeeding segments gradually becoming more elongate to the penultimate, the terminal segment about two-thirds the penultimate; verticils conspicuous, exceeding the segments in length. Head dark brown, with long yellow setæ, the occiput paler.

Mesonotum dark brown, the humeral region of the præscutum brighter; in cases the cephalic portion of the præscutum is paler, the posterior portion being largely covered by three

brownish black stripes. Pleura dark, the ventral pleurites paler, obscure yellow. Halteres pale, the base of the knobs darker. Legs with the coxæ and trochanters yellow; femora yellow, the tips broadly brownish black, the amount subequal on all the legs (about 1.25 millimeters); tibiæ yellow with the base narrowly, the apex more broadly brownish black; tarsal segments 1 and 2 obscure yellow, the tips brownish black; terminal tarsal segments uniformly darkened; legs with long, conspicuous, semi-erect setæ. Wings with a strong brown suffusion, the base and costal region more yellowish, cell Sc clearer yellow than cell C, the outer costa and stigmal region more infumed; veins pale brown, more yellowish in the costal region and along vein Cu; costal fringe (male) short. Venation: Rs relatively short, subequal to cell 1st M_2 ; m-cu at or not far beyond the fork of M, the first section of M_{3+4} subequal to or shorter than r-m.

Abdomen brownish black, the hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 20) with the outer dististyle a curved rod, the apex produced into a stout blackened point, the outer surface with conspicuous erect spinous tubercles that form a low crest, the spines becoming smaller basally. Inner dististyle short and stout, fleshy, a little shorter than the outer dististyle, provided with long conspicuous setæ. Gonapophyses long and slender, sinuous, the apex unarmed. Ovipositor with the valves very short; tergal valves with the distal half blackened.

Habitat.—Formosa.

Holotype, male, without exact locality data, October, 1926 (S. Issiki). Allotopotype, female. Paratopotype, male.

PROANTOCHA UYEI sp. nov.

General coloration obscure yellow, variegated with dark brown; all legs provided with short spinous setæ; posterior femora conspicuously flattened, the apical tooth low and obtuse; posterior tibiæ elongate, conspicuously clavate at tip, the basal tooth slender; wings whitish subhyaline, the costal region more yellowish.

Male.—Length, about 7 millimeters; wing, 10.5. Fore leg, femur, 6.7; tibia, 9; tarsus, about 4.6. Middle leg, femur, 6.8; tibia, 6.7; tarsus, about 2.9. Hind leg, femur, 7.2; tibia, 11.7; tarsus, about 2.7.

Other specimens show a range in length from about 6 to 7.5 millimeters, the wing, 9 to 11, with the measurements of the segments of the legs in proportion.

Rostrum obscure brownish yellow, the palpi dark brown. Antennæ with the basal segment brown, obscure yellow basally, the remainder of the organ dark brown; flagellar segments oval with short verticils and a short erect pubescence; terminal segment elongate. Head brownish gray, more yellowish on the orbits.

Pronotum dark brown, paler laterally. Mesonotal præscutum obscure yellow with three brown stripes, the median stripe becoming obsolete before the suture; lateral stripes paler than the median, crossing the suture onto the scutal lobes; scutum broadly pale medially; scutellum broad, pale, with a dusky spot on either side at base; postnotal mediotergite dark, pruinose medially and behind, with a small yellow spot on either side at base. Pleura brownish yellow, conspicuously variegated with dark brown on the propleura, ventral anepisternum, the ventral sternopleurite, the dorsal pteropleurite, and the meron; pleurotergite largely pale, the ventral portion darkened. In other specimens the pleura is more uniformly darkened. Halteres pale, the knobs more or less infuscated. Legs with the coxæ pale, narrowly darker basally, the posterior coxæ large; trochanters obscure yellow; remainder of legs dark brownish yellow, the tarsi beyond the base dark brown; proportions of the segments of the legs shown by the above measurements; fore and middle legs unmodified, provided with a dense vestiture of very short spinous setæ; fore tarsi longest; posterior femora conspicuously flattened, the apical tooth low and obtuse; tibiæ with a slender basal tooth, as in the males of this genus; posterior tibiæ conspicuously clavate at tip; posterior tarsi very short; claws toothed. Wings whitish subhyaline, the costal region more yellowish; stigma faintly indicated, elongate, pale brown; vein Cu indistinctly seamed with dusky; prearcular veins pale; costal veins yellowish, remaining veins dark brown. Venation: Veins strong; basal section of R_2 nearly in alignment with r-m; m-cu shortly before the fork of M.

Abdomen dark brown, the intermediate segments narrowly margined caudally and laterally with yellow; basal sternites obscure yellow; hypopygium brownish yellow. Male hypopygium generally similar in structure to the other members of the genus.

Habitat.—Japan.

Holotype, male, Yamaga, Oita-ken, Kiushiu, on the banks of the Yasakawaga, altitude 225 feet, April 22, 1927 (*Tenji Uyē*). Paratopotypes, four males, April 21–22, 1927.

This interesting crane fly is named in honor of the collector, Mr. Tenji Uyē, to whom I am indebted for many crane flies from Kiushiu. *Proantocha uyēi* is very peculiar in the extreme modifications of the legs. The short, spinous vestiture of the fore and middle, as well as the posterior legs, together with the flattened posterior femora and clavate tibiæ readily distinguish the species from the two members of *Proantocha* hitherto made known (*P. spinifer* Alexander and *P. serricauda* Alexander, of Japan).

TRICYPHONA KIRISHIMENSIS sp. nov.

General coloration pale brownish yellow; antennæ yellow; head and apex of abdomen dark brown; legs yellow, the tips of the femora and tibiæ narrowly darkened; wings pale yellowish brown, the costal cell darker; r-m connecting with R_{4+5} ; cell M_2 open.

Male.—Length, about 11.5 millimeters; wing, 13.6.

Described from an alcoholic specimen.

Rostrum and palpi brownish black. Antennæ sixteen-segmented, pale yellow, the extreme base of the first segment darkened, the terminal three or four segments dusky. Head dark brown.

Thorax pale brownish yellow, without distinct markings, the postnotum somewhat darker. Halteres relatively elongate, pale. Legs with the coxæ obscure yellow; trochanters brownish yellow; femora yellow, the tips narrowly dark brown; tibiæ brownish yellow, the tips narrowly dark brown; tarsi dark brown, the outer segments blackened. Wings with a pale yellowish brown suffusion, cell C more strongly infused; stigma pale yellow, vaguely encircled by dusky; very restricted pale brown seams at origin of Rs and along the cord; veins dark brown. Venation (Plate 1, fig. 6): Sc_2 far before the origin of Rs, the latter angulated and spurred at origin; r-m connecting with R_{4+5} at near one-fourth the length; R^{2+3} elongate; R_{1+2} a little shorter than R_2 ; petiole of cell R_4 nearly equal to r-m; cell M_2 open by the atrophy of m; m-cu subequal to the distal section of M_{3+4} .

Abdominal tergites obscure brownish yellow, with a continuous narrow dark brown median stripe; outer segments and hypopygium passing into dark brown; sternites brownish yellow, the base of the individual segments narrowly clearer yellow. Male hypopygium with the dististyle very large, bilobed, each lobe slender, with no armature other than abundant setæ of

various lengths. Interbases appearing as long, slender, chitinized spines. *Æ*deagus and gonapophyses appearing as broad blades, their tips obtuse.

Habitat.—Japan.

Holotype, male, Mount Kirishima, Kiushiu, June 9, 1926 (*S. Issiki*).

The only similar Japanese species is *Tricyphona confluens* Alexander,³ which differs in having the antennæ and legs dark brown; r-m connecting with Rs before its fork, and in other characters.

TRICYPHONA FORMOSANA Alexander.

Tricyphona formosana ALEXANDER, Ann. Ent. Soc. America 13 (1920) 260–261.

The type, a male, was from Arisan, Formosa, collected April 24, 1927, by Doctor Shiraki. The following additional records of occurrence of this small and inconspicuous but highly interesting crane fly are given: West side of Mount Daibu, Formosa, altitude 3,000 to 5,000 feet, mid-March, 1927 (*S. Issiki*). Mount Rantaizan, altitude 7,000 feet, June 2, 1927 (*S. Issiki*). The wing venation is shown on Plate 1, fig. 7.

PSEUDOLIMNOPHILA DESCRIPTA sp. nov.

General coloration dark brown; antennæ black; halteres dusky; wings with a strong brown suffusion, the stigma darker; Sc short; R_2 arising from R_{2+3+4} ; cell M_1 lacking; cell 1st M_2 relatively short.

Female.—Length, about 6.5 millimeters; wing, 6.4.

Rostrum very short, dark brown; palpi black. Antennæ black throughout; flagellar segments with long conspicuous verticils that are more than twice as long as the segments bearing them. Head dark brown, the anterior vertex and narrow posterior orbits light gray.

Pronotum gray. Mesonotal præscutum brown, more grayish laterally, the humeral region a little brighter, the dorsum with three scarcely evident darker brown stripes; pseudosutural foveæ relatively pale, a little darker than the ground color; scutum dark brown; scutellum and postnotum more pruinose. Pleura dark, the surface sparsely pruinose. Halteres dusky, the stem restrictedly paler at base. Legs with the coxæ brownish testaceous, paler apically; femora brown, a little darker out-

³ Insec. Inscit. Menst. 10 (1922) 186–187.

wardly, the bases more yellowish brown; tibiae brown, the tips weakly darker; terminal tarsal segments darker brown. Wings with a strong brown suffusion, the elongate-oval stigma darker brown; veins darker brown. Venation (Plate 1, fig. 8): Sc_1 ending before the fork of R_s , Sc_2 at its tip; R_s relatively long, gently arcuated at origin; R_{2+3+4} elongate; R_2 longer than R_{3+4} ; R_{1+2} more than twice R_2 alone; cell M_1 lacking; cell 1st M_2 relatively short, less than one-half cell 2d M_2 beyond it; m-cu just beyond the fork of M , shorter than the distal section of Cu_1 ; anterior arculus preserved.

Abdomen dark brown; sternites obscure yellowish brown. Ovipositor with the long valves darkened, the tips somewhat brighter colored.

Habitat.—Formosa.

Holotype, female, Mount Rantaizan, altitude 4,000 feet, June 2, 1927 (*S. Issiki*).

Genus LIMNOPHILA Macquart

Subgenus TRICHOLIMNOPHILA novum

Characters as in the genus, differing as follows: Antennae ranging from short to moderately elongate (*platystyla*), in the latter case, the ventral face of the flagellar segments a little protuberant; longest verticils exceeding the segments in length. Pseudosutural foveae and tuberculate pits both present. Legs with conspicuous trichiae; tibial spurs distinct. Wings with Sc relatively short, Sc_1 ending shortly before the fork of R_s , Sc_2 not far from its tip; R_2 from one-third to one-half R_{1+2} and from one-half to two-thirds R_{2+3+4} ; inner ends of cells R_4 , R_5 , and 1st M_2 in subtransverse to oblique alignment, in the latter case with cell 1st M_2 lying more basad; cell M_1 present; m-cu shortly before midlength of cell 1st M_2 ; anterior arculus preserved. Distal cells of wing (R_2 to M_3) with macrotrichiae; in some species, these even more abundant, including the distal end of cell M_4 or even Cu_1 and 1st A . Male hypopygium with the outer dististyle more or less compressed, notably so in *platystyla*, the apex bidentate; inner dististyle deeply bilobed. Ovipositor with the valves elongate, nearly straight.

Type of the subgenus, *Limnophila pilifer* Alexander. (Eastern Palearctic Region.)

Other included species are *L. breviramus* Alexander, *L. flavella* Alexander and its variety *saitamæ* Alexander, *L. platystyla* sp.

nov. and *L. macrotrichiata* Alexander of Japan and Formosa, and *L. punctum* (Meigen) of Europe.

I had formerly considered the members of this group as being referable to the subgenus *Lasiomastix* Osten Sacken, but the male hypopygium of the latter is distinct, the basistyles being elongate and the inner dististyle simple.

LIMNOPHILA (TRICHOLIMNOPHILA) PLATYSTYLA sp. nov.

General coloration brown, usually dark brown; antennæ (male) relatively elongate, the flagellar segments with their lower faces bulging; wings grayish, with abundant macrotrichiæ in the outer cells; male hypopygium with the outer dististyle very broad, greatly compressed.

Male.—Length, about 5.5 millimeters; wing, 6 to 6.2; antenna, about 2.3.

Female.—Length, about 6 millimeters; wing, 6 to 6.1.

Rostrum dark brown; palpi black. Antennæ with the basal segment of the scape reddish brown; flagellum dark brown; antennæ (male) relatively elongate, as shown by the measurements; flagellar segments with their lower faces protuberant, the surface with a delicate erect white pubescence and a few verticils. Head dark brown, the anterior vertex paler.

Mesonotal præscutum varying from yellowish brown to dark brown, darkest medially, the surface sparsely dusted; pseudosutural foveæ black; scutal lobes likewise varying from yellowish brown to dark brown, the median area a little paler than the lobes; scutellum and postnotum pale brown, the surface sparsely pruinose. Pleura dark brown, the dorsal region of the sternopleurite paler to produce a broad vague paler stripe; dorsopleural region dusky. Halteres pale brown, the base of the stem restrictedly obscure yellow, the knobs infuscated. Legs with the coxæ and trochanters obscure yellow; femora obscure yellow, the tips scarcely darkened; tibiæ brownish yellow, the tips weakly infuscated; tarsi passing into dark brown. Wings with a strong grayish suffusion, the small stigma a little darker; veins dark brown. Macrotrichiæ of cells abundant, including all distal cells from R_2 to Cu, inclusive, in some specimens even including the outer end of cell 1st A. Venation: R_2 about one-third R_{1+2} and only a little shorter than R_{2+3+4} ; cell M_1 a little longer than its petiole; cell 1st M_2 small; m-cu variable in position, ranging from before to beyond midlength of the cell.

Abdomen, including the hypopygium, brownish black, the basal segments vaguely brightened except laterally. Male hypopygium (Plate 2, fig. 21) with the outer apical angle of the basistyle somewhat conically produced. Outer dististyle very broad, greatly compressed, the apex narrowly blackened, bifid, the outer spine more slender and less curved than the inner. Inner dististyle with the outer branch expanded at apex into an obtuse head which is densely set with conspicuous setiferous tubercles; inner branch small, likewise conspicuously setiferous.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 7,000 feet, June 2, 1927 (*S. Issiki*). Allotopotype, female. Paratopotypes, one male, two females.

ATARBA LEPTOXANTHA sp. nov.

Allied to *A. pallidicornis* Edwards in the general pale yellow coloration, with the femoral tips narrowly darkened, but the mesonotum is uniformly reddish yellow.

Male.—Length, 5 to 5.2 millimeters; wing, 6 to 6.3.

Female.—Length, 5.5 to 5.8 millimeters; wing, 6.8.

Rostrum and basal segments of the palpus yellow, the terminal palpal segments brownish black. Antennæ uniformly pale yellow. Head yellow.

Mesonotum reddish yellow, the sides of the præscutum paler, more yellowish testaceous. Pleura reddish yellow. Halteres pale yellow, the knobs brighter. Legs with the coxæ concolorous with pleura; trochanters yellow; femora light yellow, the tips very narrowly but conspicuously dark brown; tibiae yellow, the tips even more narrowly and conspicuously infuscated; tarsi yellow, the terminal segments a little darker. Wings with a strong pale yellow suffusion, sometimes with faint brown streaks in the bases of cells C and Sc; veins brighter yellow. Venation as in *pallidicornis* but R_{3+4} shorter and straighter.

Abdomen brownish yellow, the terminal segments a little darker. In the female the tergites are pale brown, the sternites paler, weakly bicolorous, the apices of the segments being broadly but slightly infuscated.

Habitat.—Formosa.

Holotype, male, Tattaka, altitude about 7,400 feet, August 17, 1921 (*T. Esaki*). Allotype, female, Arisan, altitude 7,362

feet, August 24, 1921. Paratopotypes, three males, August 18, 1921.

CERATOCHEILUS FORMOSENSIS sp. nov.

General coloration dark brown; antennæ black; wings pale grayish; R_{2+3+4} long, gently sinuous; veins Cu and 1st A approximated basally for a short distance only; male hypopygium with the outer dististyle entirely blackened; gonapophyses elongate-filiform.

Male.—Length (excluding rostrum), about 4.3 millimeters; wing, 5.2; rostrum, about 4.

Rostrum elongate, almost as long as the remainder of the body, black throughout. Antennæ black. Head in front gray, the posterior vertex darker; anterior vertex of moderate width, at narrowest point approximately one-sixth the head; eyes more narrowly separated beneath, the exact distance uncertain because of a slight crushing of the head.

Mesonotal præscutum with three nearly confluent dark brown stripes; scutal lobes similarly colored; median region of scutum, the scutellum and postnotum a little paler, sparsely pruinose. Pleura dark brown, the dorsopleural membrane paler. Halteres pale, the knobs dusky. Legs with the coxæ and trochanters testaceous; remainder of legs passing into dark brown, the femoral bases narrowly paler. Wings with a pale grayish tinge, C and Sc a little brighter; veins pale brown. Macrotrichia on veins relatively long and abundant, distributed as follows: R_s , 1; basal section of R_s about 7; distal section of the same very numerous and crowded, occurring the whole length of the vein; on distal sections of M_{1+2} and M_3 ; none on R_{2+3+4} . Venation (Plate 1, fig. 9): Sc_1 ending opposite the origin of R_s , the latter shorter than the basal section of R_s ; R_{2+3+4} long, gently sinuous; vein R_s powerful, diverging widely from the other branch of R_s ; cell 1st M_2 closed; m-cu just before the fork of M; approximation of veins Cu and 1st A slight.

Abdomen brown. Male hypopygium (Plate 2, fig. 25) with the ninth tergite bearing two low lateral lobes that are sparsely setiferous. Basistyle relatively short and stout; interbasal process pale, compressed, the flattened head obtuse. Dististyle entirely blackened, the outer lateral angle produced into a slender rod; surface of the style with a few microscopic setulæ,

smaller along the margin. Gonapophyses appearing as two elongate, filiform rods.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 6,000 feet, June 3, 1927 (*S. Issiki*).

LIPSOTHRIX TAIWANICA sp. nov.

General coloration pale brownish yellow, the præscutum with four darker brown stripes; legs pale, the tarsi whitened; wings strongly tinged with brown; basal section of R_5 strongly arcuated.

Male.—Length, 5.5 to 6 millimeters; wing, 6 to 6.8.

Described from alcoholic specimens.

Rostrum very small, pale; palpi pale brown. Antennæ pale, the outer segments darker; flagellar segments oval. Head pale brownish yellow.

Mesonotum obscure yellow, the præscutum with four brown stripes, the intermediate stripes separated only by a capillary pale vitta; scutal lobes conspicuously variegated with dark brown; scutellum pale at base, the apex dusky; postnotum pale. Pleura pale, the ventral pleurites a little darker. Halteres pale. Legs relatively long and slender; coxæ and trochanters pale; femora and tibiæ pale brown, the genua vaguely paler; tarsi paling to whitish, the claws black. Wings with a strong brown tinge, the center of the disk a little paler; veins darker than the ground color; macrotrichiæ dark brown, of moderate length only. Venation (Plate 1, fig. 10): Sc_1 ending about opposite one-third the length of R_{2+3+4} , Sc_2 near its tip; R_s relatively long; R_{2+3+4} longer than the basal section of R_5 ; R_2 a little longer than R_{1+2} ; R_{2+3} shorter than R_3 ; m shorter than the outer deflection of M_3 , in cases much shorter; $m-cu$ at or close to the fork of M .

Abdomen pale brown, the basistyles more yellowish. Male hypopygium (Plate 2, fig. 26) with the basistyles relatively short and stout, the interbasal process appearing as a relatively slender pale rod. Outer dististyle heavily blackened, except at base, dilated outwardly, terminating in an acute spine; a second, slightly more curved spine on the mesal edge some distance from the tip, the space between these two spines appearing as a flattened blade. Inner dististyle pale with conspicuous setæ.

Habitat.—Formosa.

Holotype, male, west side of Mount Daibu, altitude 3,000 to 5,000 feet, mid-March, 1927 (*S. Issiki*). Paratopotypes, four males.

The discovery of a species of *Lipsothrix* in the Oriental Region is of considerable interest. *Limnophila sylvia* Alexander described from northeastern North America, should be transferred to *Lipsothrix*.

Genus **RIEDELOMYIA** novum

Rostrum short; palpi small, the terminal segment shorter than the penultimate. Antennæ (Plate 2, fig. 23) sixteen-segmented, the basal four to six segments of the flagellum closely united to form an elongate-conical fusion segment; first flagellar segment narrowed at base; segments 2 and 3 much wider than long; segment 4 a little longer than wide; remaining flagellar segments becoming elongate-cylindrical, the last segment longest; verticils of fusion segment relatively short and unilaterally arranged, on the outer segments becoming very long and conspicuous, between two and three times the segments; on the basal nine flagellar segments there are no outstanding verticils on the inner face of the segments; on the tenth and succeeding segments such a verticil is present, placed more distad than the verticils of the lateral face; terminal segment elongate, with four long terminal verticils. Vertex relatively wide. Pronotum massive. Pseudosutural foveæ large, elongate-oval; no tuberculate pits; meron greatly reduced. No tibial spurs; tarsi shorter than the tibiæ; tarsal claws relatively large, untoothed; arolia present. Wings (Plate 1, fig. 11) with Sc long, Sc₁ ending beyond the fork of Rs, Sc₂ some distance from the tip of Sc₁, being equal to or longer than m-cu alone; Rs long, strongly arcuated at origin, nearly in alignment with R₂₊₃₊₄; R₂ about two-thirds R₂₊₃₊₄ and about twice R₁₊₂ alone; cell R₂ very wide at margin; basal section of R₅ strongly arcuated; cell 1st M₂ closed, long to very long, m-cu close to the fork of M; veins Cu₁ and 2d A bent strongly into the wing margin; arculus pale but preserved. Ovipositor with relatively long valves, the tergal valves only gently upcurved.

Genotype, *Riedelomyia gratiosa* sp. nov. (Oriental Region.)

Other included species are *R. niveiapicalis* (Brunetti) of India and *R. teucholabina* (Alexander) of Fiji. This new group is named in honor of my old friend, Postamtrat M. P. Riedel, distinguished authority on the Tipulidæ.

The exact affinities of the species included in this new genus remain somewhat in doubt. The species hitherto described were placed in different genera of the Limoniini (*Dicranomyia* and *Limonia*) but a resemblance to *Teucholabis* was observed in the

case of both species. From a critical survey of the characters, as listed, it would now appear that the genus *Riedelomyia* should be placed in the Eriopterini in the general vicinity of *Teucholabis* and *Gonomyia*.

The first member of this group to be described was *Dicranomyia niveiapicalis* Brunetti⁴ from the North Canara District, Southwest India. The describer did not stress the essential characters of the fly, but in the same paper⁵ discussed a second specimen of the genus that was referred to *Teucholabis* with a query. The latter specimen has been restudied and is made the type of the genus under the name *Riedelomyia gratiosa* sp. nov. In his extremely valuable review of the Oriental Tipulidæ described by Brunetti, Edwards⁶ has reëxamined the type of *niveiapicalis*, has added further notes on the structure and coloration, and has indicated the relationship to *Teucholabis*. The probability that a new genus would be necessary to receive this fly was indicated.

The second species was described from Fiji as *Limnobia? teucholabina* Alexander⁷ and likewise was indicated as being an aberrant type that would probably require a new group for its reception. The antennæ of the latter species were not well preserved in the unique type specimen. The venation is about as in the genotype, differing as follows: Sc even longer, Sc₁ and R₁ close together at wing margin; cell R₂ not so wide, vein R₃ being strongly upcurved at outer end; cell 1st M₂ very elongate, longer than any of the veins issuing from it.

The construction of the fusion segment of the antennæ appears to vary rather surprisingly in the different species, and perhaps in the sexes of the same. *Riedelomyia niveiapicalis*, according to Edwards's observation on the dried type, has the basal six flagellar segments almost united into a large cone, the remaining segments of the flagellum very slender, with long verticils. *Riedelomyia gratiosa* has about four segments so involved in the fusion segment, while *R. teucholabina* would seem, from a study of the imperfectly preserved dried type, to have not more than three or four segments involved in the fusion.

⁴ Rec. Ind. Mus. 15 (1918) 285-286.

⁵ T. c. 306.

⁶ Rec. Ind. Mus. 26 (1924) 297.

⁷ Ann. & Mag. Nat. Hist. IX 8 (1921) 553-554.

RIEDELOMYIA GRATIOSA sp. nov.

? *Teucholabis* sp. BRUNETTI, Rec. Ind. Mus. 15 (1918) 306.

General coloration brown, the præscutum with four narrow dark brown stripes; pleura dark brown, with a narrow pale longitudinal stripe; wings grayish yellow, sparsely spotted with darker.

Female.—Length, about 7.5 millimeters; wing, 6.5.

Rostrum brown; palpi brownish black. Antennæ (Plate 2, fig. 23) as described under the genus; scapal segments brown, the basal five or six segments of the flagellum orange, the remaining segments passing into dusky. Head brown.

Pronotum pale brown above, dark brown laterally. Mesonotal præscutum brownish yellow with four narrow dark brown stripes, the intermediate pair separated from one another by a subequal distance; sublateral stripes very short; lateral margins of the præscutum and scutal lobes narrowly darkened; remainder of mesonotum chiefly dark brown, the surface more or less yellowish gray pollinose; posterior portion of the postnotum pale. Pleura almost covered by two broad dark brown stripes, leaving only the dorsopleural region and a very narrow longitudinal stripe pale, yellowish pollinose; the dorsal brown stripe extends from the cervical sclerites to the pleurotergite, passing dorsad of the halteres; the ventral stripe extends from the fore coxæ to the base of the abdomen; the narrow pale dividing stripe extends from the extreme base of the fore coxa, passing across the dorsal sternopleurite and ventral pteropleurite to the posterior postnotum, including the base of the haltere. Halteres pale, the knobs weakly darkened. Legs with the fore coxæ infumed except at base, the remaining coxæ pale; trochanters yellow; only a single (posterior) leg remains; femora yellow, the tip narrowly but abruptly whitened, preceded by a slightly narrower brown ring; tibiæ yellow, the distal fifth paling into white; basitarsi white, the outer tarsal segments more yellowish. Wings with a grayish yellow suffusion, the base and cells C and Sc brighter; a heavy spotted brown pattern, distributed as follows: At h; arculus; origin of Rs, extending caudad to vein M; Sc₂; stigma; origin of basal section of R₅; remainder of cord and outer end of cell 1st M₂; small brown marginal clouds at ends of all the longitudinal veins except Sc₁. Paler grayish brown clouds as follows: A transverse series before the wing tip, extending from costa across cells R₂, R₄, and R₅; a conspicuous wash beyond midlength of cell M adjoining vein Cu₁;

smaller washes in the anal cells adjoining vein 2d A, including two in cell 2d A and one near the base of cell 1st A; veins yellow, dark brown in the infuscated areas. Venation (Plate 1, fig. 11) as defined under the genus.

Abdomen discolored, brown, the segments appearing darker brown laterally; sternites paler brown, darker laterally, the caudal margins narrowly pale.

Habitat.—India.

Holotype, female, Parambikulam, Cochin State, altitude 1,700 to 3,200 feet, September 16 to 24, 1914 (*F. H. Gravely*). Type in the collection of the Indian Museum.

The present species is allied to *R. niveiapicalis* (Brunetti), differing especially in the details of coloration and structure. The broad dark stripes of the thoracic pleura are very different in their arrangement. The type of *niveiapicalis* has not been studied, but Edwards describes the ventral stripe as extending from the neck to the base of the abdomen. In *gratiosa* this stripe extends from the fore coxa to the base of the abdomen, the dorsal stripe being the one that includes the neck and lateral propleura.

Genus TAIWANINA novum

Rostrum slender, approximately two-thirds as long as the remainder of the head, clothed with a very delicate pubescence and long scattered setæ; palpi greatly reduced or lacking. Antennæ (Plate 2, fig. 24) twelve-segmented, short, the scapal segments enlarged, especially the large, oval second segment; flagellum with only ten evident segments, the basal one a large fusion segment which is only slightly separated from the following segment; nine flagellar segments beyond the fusion segment, these short-cylindrical, becoming longer and more slender outwardly; outer segments very elongate, with conspicuous setæ, the terminal segment with the tip narrowed, provided with four long setæ; vestiture of the flagellar segments including three distinct types of setæ, very elongate verticils, a microscopic pubescence, and small setæ set in conspicuous punctures. Anterior vertex relatively narrow, approximately twice the diameter of the first scapal segment; eyes beneath narrowly contiguous. Pronotum of moderate size, hidden beneath the produced præscutum. Tuberculate pits present, placed close together at the cephalic margin of the præscutum; pseudosutural foveæ relatively large, lying close to the margin of the sclerite. Meron greatly reduced, the middle and posterior coxæ nearly contiguous.

Legs long and slender; no tibial spurs; setæ of legs simple; claws elongate, slender, simple except for an appressed spine on outer face at about three-fourths the length; arolia lacking. Wings (Plate 1, fig. 12) with Sc moderately long, Sc₁ ending shortly beyond midlength of Rs, Sc₂ a short distance from its tip; Rs relatively short, in alignment with the basal section of R₅; R₂₊₃₊₄ at origin subperpendicular to the end of Rs, thence gently sinuous to the margin; R₂ lacking; R₃ and R₄ fused to margin, obliterating cell R₃; r-m much shorter than the basal section of R₅; cell M₁ lacking; cell 1st M₂ closed, its inner end arcuated; m-cu at or beyond midlength of the cell, equal to or longer than the distal section of Cu₁; Cu₂ very conspicuous; anterior arculus lacking. Male hypopygium with the tergite produced medially, the apex obtusely rounded. Basistyles relatively short, the two dististyles nearly terminal in position; outer style a slender, nearly straight chitinized rod terminating in two decurved teeth of which the outer is smaller; inner dististyle longer, the outer half narrowed. Ædeagus and gonapophyses inconspicuous. Anal tube conspicuous.

Genotype, *Taiwanina pandoxa* sp. nov. (Oriental Region.)

Despite the loss of cell R₃ of the wing, the new genus *Taiwanina* appears to be placed correctly in one of the lower subtribes of the Eriopterini, near such groups as the Gonomyaria, Toxorhinaria, and Claduraria, with all of which it shows some features in common. The slightly elongated rostrum, with very reduced palpi, together with the structure of the antennæ, reminds one very strongly of the Toxorhinaria; but the setæ of the legs are simple and it seems probable that the relationship is not especially close. The combination of antennal and hypopygial structure, and the wing venation, separates this beautiful little fly as an isolated type. At first sight one is reminded by the venation and short rostrum of the subtribe Heliaria, but the structure of the antennæ and thorax renders such an assignment less probable.

TAIWANINA PANDOKA sp. nov.

General coloration black; pronotum and a longitudinal stripe on the thoracic pleura yellow; halteres yellow, the knobs dark brown; femora black, the bases yellowish; tibiæ orange, the base and apex white; basitarsi obscure orange, the base infuscated, remainder of tarsi white; wings strongly infumed, variegated with yellow, the costa broadly so; intermediate abdominal sternites with a whitish spot on either side at base.

Male.—Length, about 5 to 5.5 millimeters; wing, 5 to 7.2.

Rostrum and remainder of head black. Antennæ brownish black throughout.

Cervical sclerites black, brighter above. Pronotum light yellow. Mesonotal præscutum brown, darker behind, paling into yellowish brown in front, without evident pattern; tuberculate pits and pseudosutural foveæ nearly concolorous; remainder of mesonotum dark brown. Pleura brownish black with a conspicuous pale longitudinal stripe extending from the propleura, narrowed behind, ending beneath the wing root, posteriorly with the surface whitish pruinose. Halteres of moderate length, yellow, the knobs dark brown. Legs with the fore coxæ pale yellowish brown, darker apically, the remaining coxæ and all trochanters black; femora black, the bases broadly and conspicuously yellow, the middle femora almost entirely blackened; tibiæ bright orange, the base narrowly pure white, the apex more broadly of this color, the latter preceded by a more or less distinct darkened ring; basitarsi obscure orange, the extreme base infuscated, the apex and remainder of the tarsi pure white, the terminal segment a trifle more yellowish. Wings strongly infumed, the prearcular and costal regions broadly and conspicuously bright yellow, more rarely a trifle obscured, sending large caudal extensions caudad over the arculus, in cell R before Rs and in cell R₂ beyond Rs; conspicuous yellow marginal spots in outer ends of cells R₂ and R₄; small paler spots in outer ends of cells R₅, 2d M₂, M₃, and M₄; large geminate yellow spots at margin on either side of both anal veins; vague pale centers in the cells adjoining the cord; posterior arculus dark; veins pale brown, C, Sc, and R clear light yellow except where traversed by dark areas. Venation (Plate 1, fig. 12) as discussed under the genus; Rs relatively short, strongly arcuated to weakly angulated at origin; basal section of R₅ variable in length; cell R₄ strongly widened at outer end; anal veins bent abruptly into the margin.

Abdomen black; sternites 3 to 7 laterally at base with a conspicuous oval whitish spot; hypopygium dark, the tergal region paler. Male hypopygium as discussed under the genus.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 6,000 feet, June 7, 1927 (*S. Issiki*). Paratopotypes, two males, June 3 to 7, 1927; paratype, alcoholic male, Rengechi, altitude 1,500 to 2,000 feet, end of March, 1927 (*S. Issiki*).

Taiwanina pandoxa is a striking fly similar to no species so far described.

MOLOPHILUS PALLIDIBASIS sp. nov.

Belongs to the *gracilis* group; allied to *M. costalis* Edwards; antennæ whitish; mesonotum pale brown; wings with a grayish yellow tinge, the costal region brighter yellow; male hypopygium with the dorsal lobe of the basistyle a cylindrical fleshy lobe that is setiferous to the blunt apex.

Male.—Length, about 3.5 millimeters; wing, 4.3.

Described from an alcoholic specimen.

Rostrum and palpi brown. Antennæ with the first scapal segment dark, the remainder of the organ whitish. Head ocherous brown, the vertex a little darker.

Pronotum whitish above, darker laterally. Mesonotal præscutum pale brown, the præscutum with scarcely differentiated paler stripes. Pleura brown, the dorsopleural region whitened. Halteres dusky, the knobs a little more whitish. Legs with the coxæ and trochanters obscure yellow; remainder of legs obscure yellow, the tarsi passing into darker. Wings with a grayish yellow suffusion, the costal region brighter yellow; veins brownish yellow, those in the costal region brighter. Venation: R_2 lying proximad of the basal section of R_5 ; petiole of cell M_3 more than twice m-cu; vein 2d A ending about opposite m-cu.

Abdominal tergites brown, the sternites paler. Male hypopygium (Plate 2, fig. 27) with the dorsal lobe of the basistyle relatively long and slender, cylindrical setiferous to the tip; mesal lobe shorter and broader; a blunt setiferous tubercle near base of the style. Outer dististyle relatively slender, the base expanded, the remainder of the style heavily blackened, the tip narrowed into an acute curved spine; surface of the style with microscopic appressed spinules. Inner dististyle subequal in length to the outer, sinuous, the apex a little widened, obtuse, the inner margin produced into a small spinous point; inner margin of the stem with a few microscopic spinules.

Habitat.—Formosa.

Holotype, male, west side of Mount Daibu, altitude 3,000 to 5,000 feet, mid-March, 1927 (*S. Issiki*).

MOLOPHILUS ALBOCOSTALIS sp. nov.

Belongs to the *gracilis* group; allied to *M. costalis* Edwards; antennæ whitish; mesonotum dark brown, the lateral margins conspicuously yellowish white; wings tinged with brown, the costal margin whitish; a small dark brown spot on the anterior

arculus; male hypopygium with the dorsal lobe of the basistyle a flattened glabrous blade, the tip obtusely rounded.

Male.—Length, about 2.6 to 3 millimeters; wing, 3.3 to 4.2.

Rostrum and palpi dark brown. Antennæ with the basal five or six segments whitish, the outer segments more infuscated. Head yellow, the center of the vertex with a large oval dark brownish gray spot.

Pronotum yellowish white, darker laterally; anterior lateral pretergites yellowish white. Mesonotal præscutum brownish gray, the lateral margins yellowish white; remainder of mesonotum dark brown. Pleura dark brown. Halteres dusky, the base of the stem restrictedly paler. Legs with the coxæ dusky, the middle and hind coxæ a trifle more yellowish; trochanters yellowish testaceous; remainder of legs dark brown, the tarsal segments darker. Wings with a brownish tinge, the costal margin whitish; a small dark brown spot on the anterior arculus; veins pale brown, yellowish in the costal region; macrotrichiæ dark brown. Venation: R_2 lying proximad of the basal section of R_5 ; petiole of cell M_1 more than twice m-cu; vein 2d A relatively short, ending some distance before m-cu.

Abdomen dark brown, the hypopygium brighter. Male hypopygium (Plate 2, fig. 28) with the basistyle relatively long and slender, the dorsal lobe a flattened glabrous blade, the apex broadly rounded; mesal lobe much shorter, obtuse, provided with a few conspicuous setæ; mesal tubercle of the basistyle lying on distal half of the style. Outer dististyle a slender blackened rod, narrowed gradually to the acute curved apex, the surface with abundant microscopic appressed spinules. Inner dististyle longer and broader, near midlength markedly constricted, the apical half narrowed to the acute tip, this expanded headlike portion with abundant microscopic spinules.

Habitat.—Formosa.

Holotype, male, Mount Rantaizan, altitude 7,000 feet, June 2, 1927 (*S. Issiki*). Paratopotypes, several males.

Molophilus costalis Edwards (Plate 2, fig. 29) and *M. arisanus* Alexander (Plate 2, fig. 30) are readily distinguished from the two allied species described at this time by the elongate spinous dorsal lobe of the basistyle of the male hypopygium. The structure of the styli of these four Formosan species is shown in Plate 2, figs. 27 to 30.

ILLUSTRATIONS

[Legend: b, basistyle; i, interbase; o, outer dististyle; R, radial vein and its branches; Rs, radial sector; t, tergite. Venational terminology used, Comstock-Needham-Tillyard, as modified by Alexander. Hypopygial terminology used, Crampton.]

PLATE 1

FIG. 1. *Nesopeza circe* sp. nov., wing.

1a. *Nesopeza circe* sp. nov., detail of radial field of wing.

2. *Limonia fraudulenta* sp. nov., wing.

3. *Limonia ebriola* sp. nov., wing.

4. *Eurhamphidia inelegans* sp. nov., wing.

5. *Protohelius issikii* gen. et sp. nov., wing.

5a. *Protohelius issikii* gen. et sp. nov., detail of radial field of wing.

6. *Tricyphona kirishimensis* sp. nov., wing.

7. *Tricyphona formosana* Alexander, wing.

8. *Pseudolimnophila descripta* sp. nov., wing.

9. *Ceratocheilus formosensis* sp. nov., wing.

10. *Lipsothrix taiwanica* sp. nov., wing.

11. *Riedelomyia gratiosa* gen. et sp. nov., wing.

12. *Taiwanina pandoxa* gen. et sp. nov., wing.

PLATE 2

FIG. 13. *Tipula tetracantha* sp. nov., details of male hypopygium.

14. *Limonia fraudulenta* sp. nov., male hypopygium.

15. *Limonia remissa* sp. nov., male hypopygium.

16. *Limonia ebriola* sp. nov., male hypopygium.

17. *Dicranomyia nesomorio* sp. nov., male hypopygium.

18. *Protohelius issikii* gen. et sp. nov., male hypopygium.

19. *Dicranoptycha formosensis* sp. nov., male hypopygium.

20. *Dicranoptycha geniculata* sp. nov., male hypopygium.

21. *Limnophila (Tricholimnophila) platystyle* sp. nov., male hypopygium.

22. *Liogma pectinicornis* sp. nov., antenna of male.

23. *Riedelomyia gratiosa* gen. et sp. nov., antenna of female.

24. *Taiwanina pandoxa* gen. et sp. nov., antenna of male.

25. *Ceratocheilus formosensis* sp. nov., male hypopygium.

26. *Lipsothrix taiwanica* sp. nov., male hypopygium.

27. *Molophilus pallidibasis* sp. nov., male hypopygium.

28. *Molophilus albocostalis* sp. nov., male hypopygium.

29. *Molophilus costalis* Edwards, male hypopygium.

30. *Molophilus arisanus* Alexander, male hypopygium.

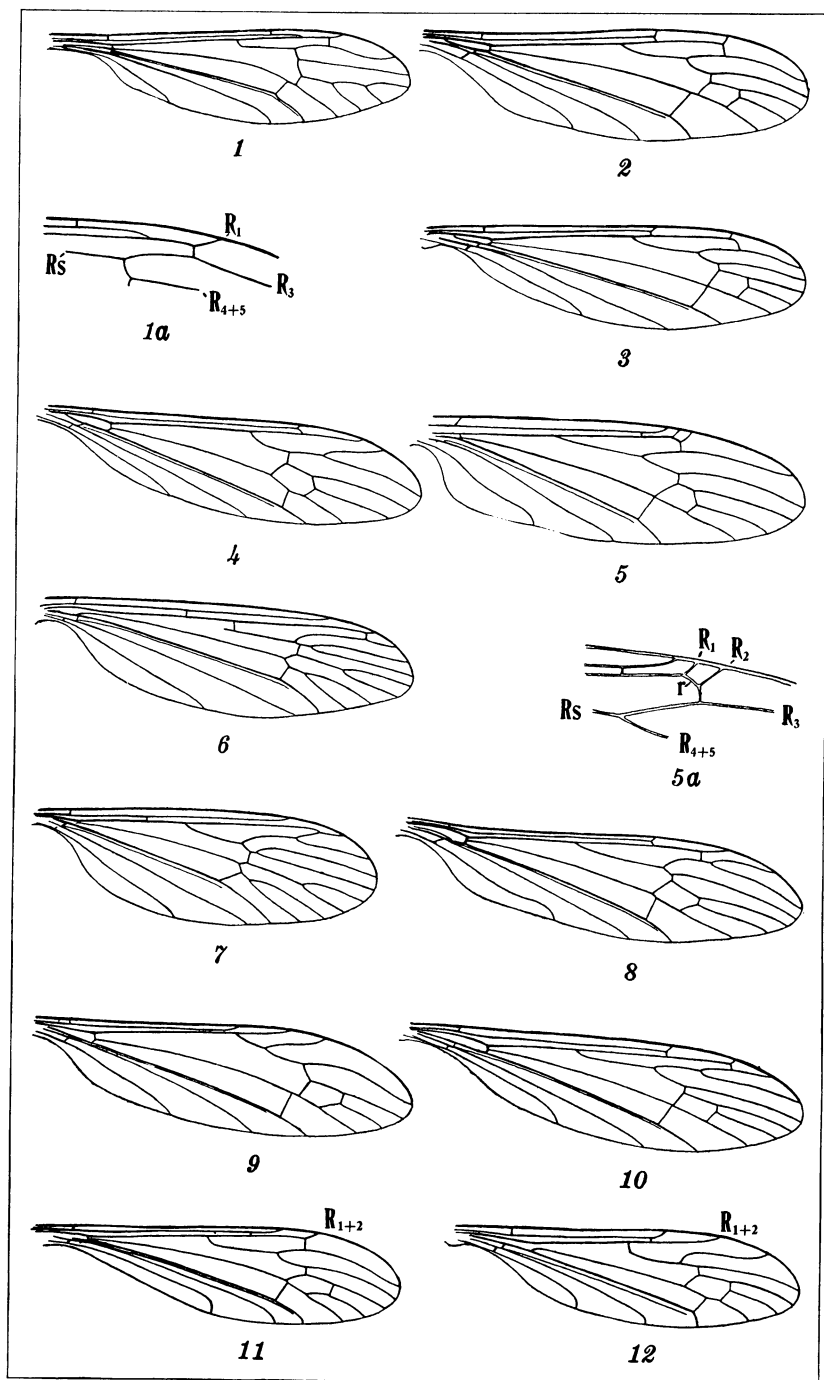


PLATE 1.

ERRATA

Page 55, in the fourth line from the bottom, *for* Chamberlain.
read Chamberlin,

Page 57, in line 20, *for* giving birth *read* the liberation of

Page 57, in footnote 5, *for* (1912) *read* (1913)

Page 58, in the third paragraph, line 2, cancel the comma.

Page 61, insert a center head INSECTA above the center head
ORTHOPTERA

Page 62, in the quotation from Imms, in line 5, *after* soil
insert very much after the manner of the "casts" of earthworms.
In many parts of the tropics there is scarcely a cubic yard of
soil

Page 63, footnote 11, in line 2, *for* 234 *read* 243

Page 70, in line 26, *for* by others. *read* by others *for* *Ochro-*
myia.

Page 70, in line 29, *for* *Ochrimyia*. *read* *Ochromyia*.

Page 72, in the second line from the bottom, *for* *gibolensis*
read *gilolensis*

Page 73, to footnote 29, *add* 210.

Page 75, in the thirteenth line from the bottom, *for* centi-
meters, *read* centimeters;

Page 75, in the third line from the bottom, cancel both commas.

Page 76, in the sixth line of the quotation, cancel the semi-
colon.

Page 76, in the sixth line from the bottom, *for* *chrysogona*
read *chrysozona*

Page 80, in line 19, *for* Notodontidæ *read* Notodontidæ

Page 82, to footnote 37, *add* 325-326.

Page 83, in line 24, *for* *Chalbyion* *read* *Chalybion*

Page 83, in the thirteenth line from the bottom, *for* of Bull.
read of my Bull.

Page 83, in the eleventh line from the bottom, *for* *interudens*
read *intrudens*

Page 86, in the second paragraph, line 2, and in footnote 43,
for 1927 *read* 1928

Page 87, in the second paragraph, line 5, *for* *Cephalomomyia*.
read *Cephalonomyia*.

Page 93, for line 4, *read* of the nests of certain other ants, like those of *Anoplolepis*—

Page 96, to footnote 57, add the date 1923.

Page 97, line 8, delete the first comma.

Page 97, in line 11, *for* pluræ, *read* plura,

Page 97, in line 22, *for* mesopluræ, *read* mesoplura,

Page 98, in line 5, *for* margination *read* emargination

Page 98, in line 17, *for* margins *read* margin

Page 100, in line 16, *for* reticulate; drawn *read* reticulate, drawn

Page 100, in line 17, *for* place; *read* thorn;

Page 105, in the ninth line from the bottom, cancel “and not very loud.”

Page 108, in footnote 65, *for* 187. *read* 185.

Page 108, in footnote 66, *for* 27: 408. *read* 27 (1920) 409.

Page 109, cancel the center heading.

Page 112, in footnote 69, *for* (1922). *read* (1907) 1022.

Page 112, in footnote 70, *for* (September, 1925). *read* (1925) 326.

Page 118, in the description of Plate 7, fig. 1, *for* *celebensis* *read* *celebesensis*

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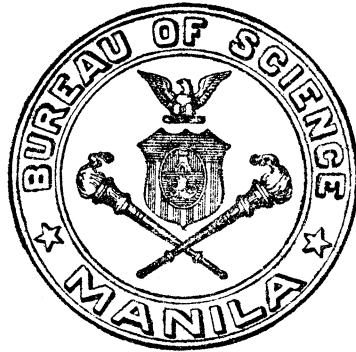
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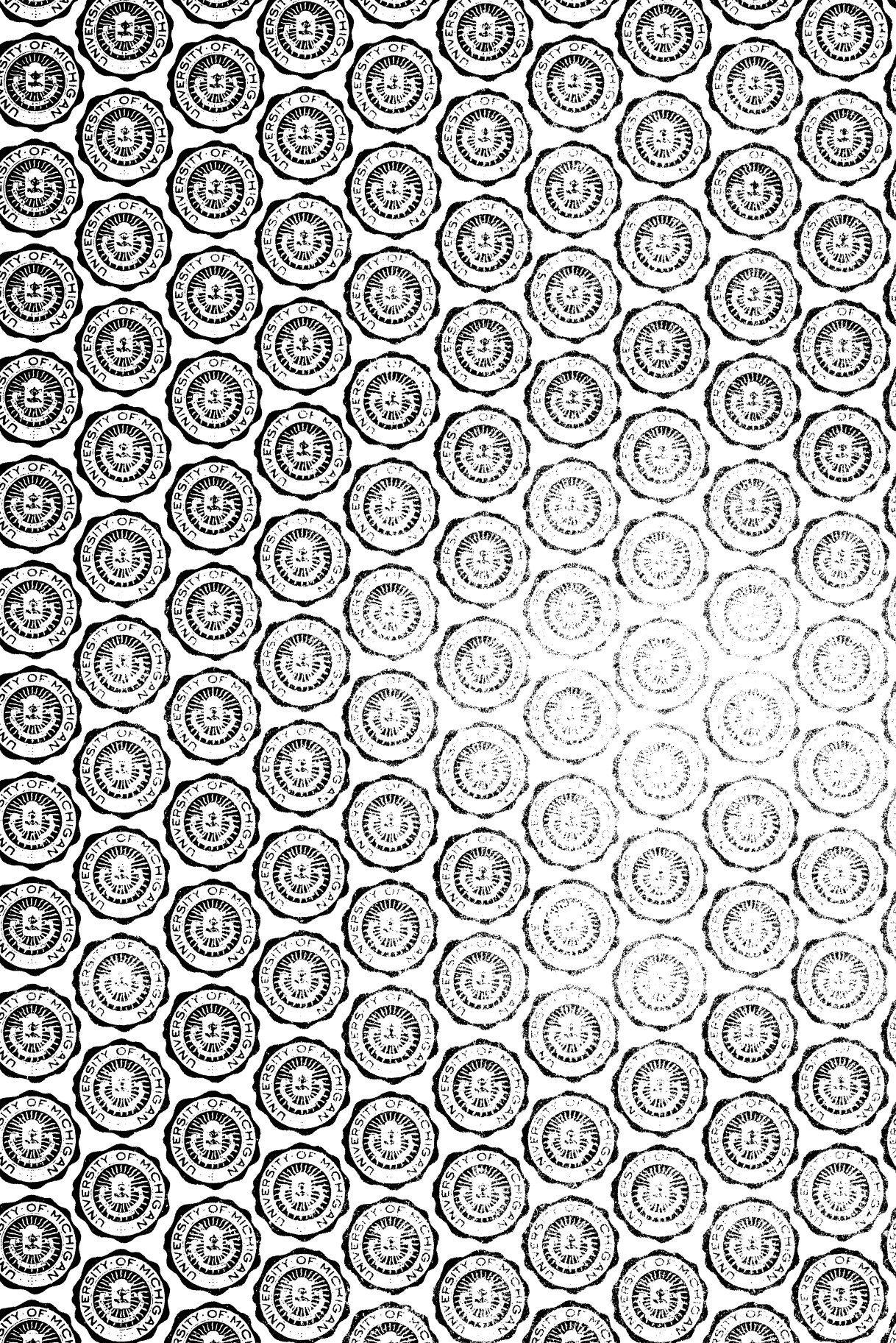
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